Sky and Telescope

FEB 2 1944

Paricutin volcano at night

Vol. III, No. 4
FEBRUARY, 1944
Whole Number 28
20 cents

★

Mexican Volcanoes
The Law of Diminishing Returns
American Astronomers Report
Comet van Gent-Peltier
This Earth of Ours
Stars for February

JUPITER GOES INTO HIDING

At 8:01 a.m., E.W.T., January 13th, Peter A. Leavens caught the moon and Jupiter with the 10-foot (4-inch aperture) camera of the Amateur Astronomers Association, set up at Sayville, Long Island. The moon is very bright compared to the planet, whose satellites have already been occulted. South is at the top. Early reports indicate the occultation (or conjunction) was observed under generally favorable conditions in most of the United States.

In Focus

EXPLANATIONS concerning the inversion of lunar relief continue to come in. Some are the results of various experiments with our back covers; some are arbitrary; some agree on principle; others are widely divergent. Several readers have come to the conclusion that the inversion happens under any conditions, without control by the observer; others contend that they can voluntarily change from craters to "mesas," and back again.

This month's back cover is of a portion of the moon overlapping part of last month's, as it includes in its lower left corner the crater Timocharis and at its central left edge the massive Eratosthenes.

Copernicus, best-known crater on the moon, is just above the center of the picture. Its wide walls are terraced up to relatively sharp ridges some 12,000 feet above the interior. The whole diameter is 56 miles, and the crater floor is 40 miles across, containing what is sometimes called a multiple central peak. Copernicus is the center of a system of bright rays extending over all features of the lunar terrain and best seen in nearly vertical sunlight.

The pattern of the hundreds of crater pits to the left of Copernicus may be suggestive of their origin. They are not to be confused with craterlets, which cast exterior shadows instead of the interior shadows seen in the crater pits. Above and below this region may be seen a number of low, serpentine ridges, thought by many to be flow markings caused by movements of the once viscous surface.

The following craters may be identified; the first measurement is in inches from the top, the second from the left edge of

(*Continued on page 19*)

SKY and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

The Editors Note .

THE PLANETARIUMS of America have been doing their share of wartime education, either directly in collaboration with the armed services, or by offering demonstrations and courses in navigation, mathematics, meteorology, and related sciences to astronomy. Visualization of the relations of various celestial co-ordinates, understanding of the astronomical triangle, discovery of how to learn the stars, these often first come to aviators, naval personnel, and even experienced seamen as a result of visits to a planetarium for a lecture on navigation. Most of the members of planetarium staffs are busily engaged in furthering the war effort in one way or another.

Now, announcement of the establishment of an Astronomy Clinic at The Franklin Institute in Philadelphia, with demonstrations in the Fels Planetarium, indicates the ever-widening part the planetarium is playing as an educational medium. Fifth-grade students of the Friends Select School enact the roles of earth, moon, sun, and other heavenly bodies and move solemnly in their orbits, while teachers in the Philadelphia area attend, **without charge,** lecture-demonstrations designed to suit teachers of all grades from kindergarten through high school. In addition to an instruction manual which has been prepared, the use of simple models is demonstrated: paper boxes, ping pong balls, candles, pieces of paper, lengths of string, these are all shown to be of value in teaching the principles of astronomy.

Response to the Fels program clearly shows the need for such courses as these, and cities which do not have planetariums now might well consider the value of such installations in planning their educational expansion. American-built projectors are expected to cost very much less than the foreign instruments, and to perform as well; central locations should be chosen, and buildings designed for utility, service, and economy, as well as beauty.

VOL. III, NO. 4
Whole Number 28

CONTENTS

FEBRUARY, 1944

FRONT COVER: The very young Paricutin volcano at night, March 5, 1943, photographed by Evelyn Hofer. A break-through of lava from the base of the volcano (toward left of photo) shortly before, and the subsequent caving in of the volcanic ash at that side, results in the conic appearance of the cone at this date, rather than the appearance of a truncated cone which is revealed in the photographs accompanying the article. (See page 3.)

MEXICAN VOLCANO — L. C. Graton 3
THE LAW OF DIMINISHING RETURNS — Joel Stebbins 5
AMERICAN ASTRONOMERS REPORT 9
COMET VAN GENT-PELTIER — G. Van Biesbroeck 11
THIS EARTH OF OURS — William H. Barton, Jr. 12

Amateur Astronomers 15
Astronomical Anecdotes 4
Beginner's Page 20
Books and the Sky 16
Gleanings for A.T.M.'s 18
In Focus 2
News Notes 14
Observer's Page 22
Planetarium Notes 23
Stars for February 21

BACK COVER: A portion of the moon around the crater, Copernicus, photographed on October 26, 1937 by J. H. Moore and J. F. Chappell, using the visual focus of the 36-inch refractor at Lick Observatory. The age of the moon was 22.06 days. This is part of Plate XV in the collection of *Astronomical Photographs Taken at the Lick Observatory,* and is enlarged from the same negative as the covers appearing in our December, 1943, and January, 1944, issues. For a description of this portion of the moon, see "In Focus."

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscription: $2.00 per year in the United States and possessions; $2.50 foreign (including Canada). Single copies: 20 cents. Make checks and money orders payable to Sky Publishing Corporation. Send notice of change of address 10 days in advance. Circulation manager: Betty G. Dodd.

Editorial and general offices: Harvard College Observatory, Cambridge 38, Mass. Advertising director: Fred B. Trimm, 19 East 48th Street, New York City; ELdorado 5-5760.

Mexican Volcano

By L. C. Graton, *Harvard University*

The sudden birth and rapid growth of the volcano, Paricutin, just a year ago this month, while bringing destruction to a large area near it, has proved of great interest to the public and to scientists who have been busy observing and studying the volcano and its attendant phenomena. Dr. L. C. Graton, professor of mining geology at Harvard, spent nearly two months in the region last spring, making field trips to the volcano, and flying over it twice. The story here, adapted from a C.B.S. broadcast in August, 1943, given under the auspices of Science Service by Prof. Graton, is largely the story of his own observations and studies. Up to now, the volcano has continued in fluctuating but vigorous activity. Recent changes include the development of a small, parasitic cone.

BY GOOD fortune, the very birth of the newest of the world's volcanoes, Paricutin, in the state of Michoacan, Mexico, was witnessed by an observer on the spot. In the late afternoon of February 20th last year, Dionisio Pulido, intelligent Tarascan Indian, was preparing his cornfield for planting. For two weeks his native hamlet of Paricutin, 200 miles west of Mexico City, had been experiencing earthquakes of growing intensity. Alert on this account, Pulido suddenly heard a deep rumbling underground. Before his startled gaze there surged upward from a slight depression a column of dusty yellow soil. With increasing roar and mounting vigor, the column changed to darker color, as fragments of rock from greater depth emerged from a growing rent in the earth. Then, rapidly succeeding explosions of deafening intensity began hurling high in the air fragments which in the waning daylight were brightly incandescent. These, falling back, started building a cone of debris around the vent.

When one day old, the cone had attained a height of about 100 feet and a base four times as wide. Also, through one side of the base, there was emerging a flow of molten but viscous lava which began to spread out as a rough layer. During the next three weeks it covered nearly a square mile to a depth of some 50 feet. Meanwhile, the explosions, caused by sudden release of gases, continued from within the crater, spraying the ascending lava into fragments of varying sizes: rounded masses from a few pounds to many tons each, known as bombs; smaller, porous fragments called cinder; tiny sizes, volcanic ash or sand; and on down to impalpable dust. All this quickly chilled as ejected. Most of it fell directly back to build the cone ever higher. Although this upsurging column looked black by day, at night the red-hot bombs, shot out at various angles, produced titanic fireworks of stunning beauty.

By mid-March, the lateral outflow of lava ceased. And immediately the activity within the crater changed in nature. Explosions, still incessant and powerful, sounded more muffled. The proportion of smaller fragments increasing, a spouting black pillar of mixed debris and gases rose to a height of two miles. Great quantities of ash were spread about, first covering the adjacent fields and the new lava flow with a gritty, somber pall, and gradually extending this both in thickness and to an ever-widening circle eventually tens of miles in radius. Finest black dust fell at times even as far as Mexico City.

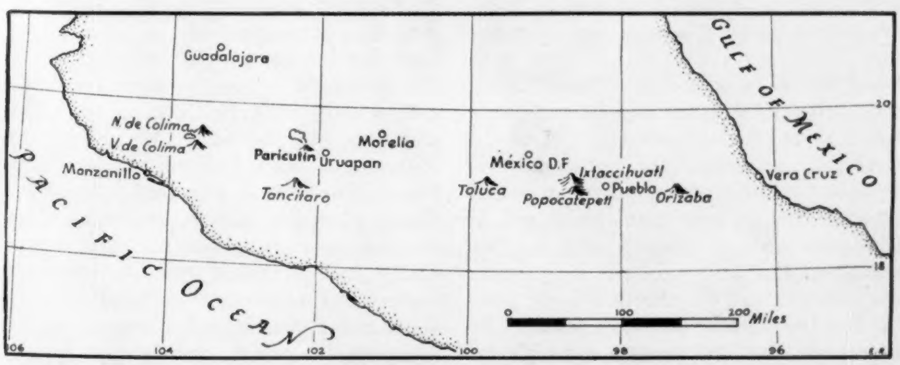
Four times since, however, in April, June, July, and August, there was brief reversion to the earlier phase of activity. Lava flows broke through at other parts of the base of the cone, while a far

A view into the crater from the summit of the nearest old volcanic cone on the west, April 15, 1943. Photo by the author.

smaller amount of ash was ejected from the crater. In each instance, however, the new flows ceased within a few days, and the crater resumed violent emission of ash in enormous quantities.

Of course, the new phenomenon aroused much interest and curiosity throughout Mexico. At all hours of the day or night, people came to see this chapter in the geologic drama, even though it is a tiring journey from the nearest city to the volcano, about 20 miles by automobile over an ash-clogged road and then about three miles on burro-back.

The commonest question asked about the volcano is as to how long its activity will continue. The answer can only be guessed at, with the help of analogy. In this great volcanic region of central Mexico, a few majestic peaks like Colima, Popocatepetl, and Orizaba, tower above literally thousands of cinder cones ranging from a few hundred to one or two thousand feet high. Almost certainly, Paricutin is merely the newest member of this family of lesser volcanoes. Something over 1,000 feet high after six months of activity, it has equalled or surpassed the size of most of its sisters. That Paricutin's rate of growth is typical for the class is indicated by the fact that one of the group, only 50 miles away, broke out as a new volcano in 1759, and after nine months of eruption had built a main cone a little higher than



A portion of south central Mexico showing the location of Paricutin in the volcanic belt. Positions of the famous grand volcanoes are indicated, but thousands of smaller ones are not shown.

The cone of Paricutin as seen from the north across the ash-covered lava flow. An inner cone is growing within the main one. This phenomenon was observable for just a few days, the inner cone soon afterward growing sufficiently large to merge with the outer. Photo by the author, April 20, 1943.

Paricutin now is. But since the *volume* of a cone must be multiplied eight times to give a doubling in height, Paricutin would have to continue growing at its present rate until 1947 to be twice as high as now. One might hazard the guess that it will not live so long.

Fortunately, there has been no loss of life. Advance of the lava flows has not been at a dangerous pace. The first great flow stopped some hundreds of yards short of Paricutin hamlet; one of the larger flows last June stopped just short of the nearest houses, but by then the populace had been evacuated.

The chief loss is caused by the blanket of ash. The houses of Paricutin are half buried by it. A larger town, twice as far away, is now mainly depopulated and many roofs have caved. Great areas of the turpentine forests are likely to die. All forage and crops have been overwhelmed for many miles around. Although the fresh ash holds the needed chemical elements, these will not be in a condition available for plant growth until after thorough decomposition by the slow process of weathering. Hence, wherever the old soil is buried under new ash to the depth feasibly reached by plowing, the land must long remain unproductive. As this fatal thickness of ash is extending each day the volcano continues in action, some hundreds of square miles of fertile cultivation may thus be erased for several generations.

Paricutin, probably destined to remain relatively small and simple, is unlikely to repeat some of the most spectacular features of the world's great volcanoes. Yet it fully justifies the geological study now being directed upon it. A volcano is, at best, difficult to analyze. A new volcano, being itself least complex, may simplify many of the toughest questions. Although Paricutin will not solve, it will surely shed valuable light upon such fundamental problems as the depth at which volcanoes originate, the origin and the intensity of the heat at that depth, how the power manifested in volcanic eruption is brought into operation, and why volcanoes are relatively rare and sporadic instead of being common occurrences in both time and place.

But volcanoes can do more than merely help to explain themselves. Since our planet was once wholly in the molten state but has since solidified at least on the exterior, volcanoes, and the closely related phenomena, hot springs, geysers, and fumaroles, represent man's only *direct* contact with the interior heat and the varied processes connected with it. Many branches of geological science thus have most intimate relation to volcanism.

For example, although I have tried to see as many volcanoes and hot springs in various parts of the world as it has been feasible for me to reach, my own interest has not been in these thermal features for themselves alone, but chiefly for their help in explaining the origin of that great family of ores of the metals which likewise have their source in the hot depths. Gradually, at the hands of many investigators, volcanoes and ore deposits are each contributing to understanding of the other — one of the countless illustrations of the interdependence of pure science and its useful application.

ASTRONOMICAL ANECDOTES

SOME DELAYED TELESCOPES, AND A SINGLE STUDENT

THOSE of us who meet large numbers of the public often are asked, "When will that new telescope in California be finished?" The suspension of the optical work for the duration of the war is an easily explained point, although no one has described many of the factors causing delay not attributable to the war.

There have been other delayed instruments, one of which was last year described in *Sky and Telescope* (March, 1942). I have just received a copy of Tomo XIV, No. IV, of *Revista Astronomica,* containing the description of the events connected with the inauguration of this powerful Southern Hemisphere telescope. A part of this celebration was a detailed story of the history of the 60-inch reflector of the Bosque Alegre Observatory, about 30 miles from Cordoba, Argentina.

It was 35 years ago this month that Charles D. Perrine was invited to leave the United States and come to be director of the Cordoba Observatory. In only four months, he submitted several plans for a new large telescope and observatory. In 1910, G. W. Ritchey was asked to bid on grinding a 60-inch mirror; in 1911, Warner and Swasey were asked to bid on a dome from 15 to 18 meters in diameter. In 1912, the Argentine Congress appropriated an initial $95,000 toward the total estimated at $280,000. About a month later, Ritchey explained that it would not be possible for him to make the mirror for the price he had previously set, $13,500. The new price, $16,000, seemed too high for the authorities in Argentina.

Perrine and an assistant, James Mulvey, undertook the work themselves. A special building was constructed in 1914 for the optical work. The glass disk had been ordered in September of 1912; it was to be, in finished form, 61 inches in diameter and eight inches thick. The famous Saint-Gobain firm delivered it in good condition in March, 1913. Actual grinding was begun in 1914; in 1915, Mulvey died, and was succeeded by another American mechanic, Thomson Fisher.

The mounting was ordered from Warner and Swasey in 1915, but work on it was not initiated until 1922, because of war contracts held by the Cleveland firm. In 1921, Fisher resigned, convinced that he could accomplish nothing further, and returned to the employ of Warner and Swasey, and the optical work was suspended for 10 years. Meanwhile, however, the dome and mounting were installed in 1922. Then from 1931 to 1936, some more work was done on the mirror, but was again suspended as the first Argentinian director, Juan Jose Nissen, succeeded Perrine. Examination of the whole situation led to the conclusion that the mirror should be sent to some reputable optical shop to be finished: in 1938, the disk was shipped to J. W. Fecker in Pittsburgh, who finished the job in a year. The mirror possessed a beautiful figure when I saw it in the Fecker shop in August, 1939, about the time it was tested and accepted by Dr. Enrique Gaviola, the present director of the National Astronomical Observatory of Cordoba, to which the Bosque Alegre station is attached.

Dr. Gaviola has made original con-

(*Continued on page 15*)

THE LAW OF DIMINISHING RETURNS

By JOEL STEBBINS, *Washburn Observatory, University of Wisconsin*

Read before the American Astronomical Society, November 6, 1943

IN THE *Encyclopaedia Brittanica* under the heading, "Law of Diminishing Returns," we find that this law was first stated in relation to agriculture.

"An increase in the capital and labor applied to the cultivation of land causes in general a less than proportionate increase in the amount of produce raised unless it happens to coincide with an improvement in the arts of agriculture.

"In economics, then, the law of diminishing returns is merely a precise statement of what is ordinarily recognized in the affairs of the working world. Everybody knows that, after a certain point, work in given conditions yields a diminishing return unless a better method is invented applicable to those conditions."

We in this society naturally include astronomy in the affairs of the working world, and it may be instructive to trace some of the applications of the law of diminishing returns in our own field. To begin with, this law took hold of the increasing size of refracting telescopes and brought further development to a close with the completion of the 40-inch Yerkes refractor some 50 years ago. True, it was the rediscovery of the possibilities of the reflecting telescope that turned the construction of new instruments into the other form. But even if there had been no reflectors it was obvious from geometrical and optical principles, not to mention atmospheric limitations, that each increase in size of the objective of a refractor was accompanied by less than a proportionate increase of power.

The same law is now holding for reflectors even if the 200-inch, as we hope, should turn out to be a complete success. I understand that at Mount Wilson the 100-inch reflector cost about four times as much as the 60-inch, while the 200-inch will cost 10 times as much as the 100-inch. No one thinks for a moment that the resulting gain in power will be proportional to the outlay. These facts are elementary to astronomers, but to the layman we might quote the simple rule that the cost of a good telescope can be roughly proportional to the cube of its linear aperture.

Despite these facts, how many of us, if we were offered the money for a well-endowed 100-inch telescope, would have the moral courage to say that we would prefer to build an 80-inch and use the balance of the funds for additional improved attachments and for even better operation? The difference between 80 and 100 inches is practically not as important as the difference between poor and good seeing. Ask any observer on Mount Wilson which he would rather have, a fine night with the 60-inch or a poor, or even a fair, night with the 100-inch. The answer does not mean that the larger instrument has not been a success. Certain things have been done with it for the first time which had not been done with smaller reflectors. While experience has shown that some discoveries could have been made with smaller telescopes, the fact remains that they were not made. Near the limit of observational detection the extra power of the largest telescope available is an advantage.

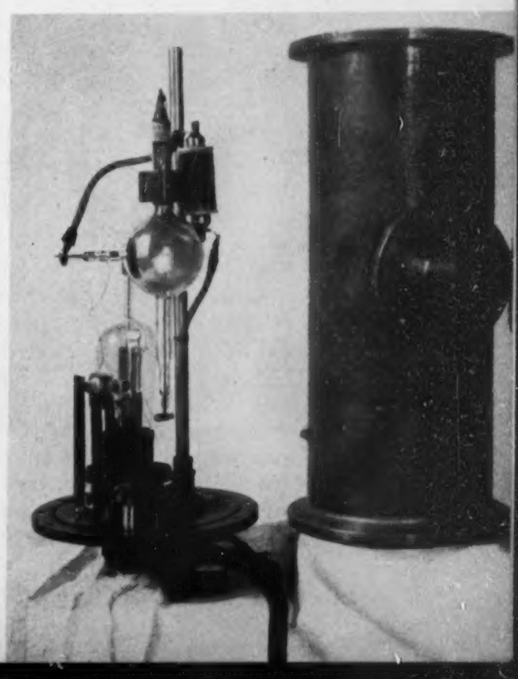
My own experience with the law of diminishing returns began in another fashion years ago when I was a night assistant at the Crossley reflector of the Lick Observatory. My chief at the time was Charles D. Perrine who, to say the least, was an indefatigable observer. Those were the days, or rather the nights, of long exposures, perhaps only two plates per night, and toward dawn it used to seem to me that the last 15 minutes of a four-hour exposure were time purely wasted. Though I did not venture to say so, I was sure that on the resulting plate no one could tell the difference between an exposure of four hours and one 15 minutes shorter, so that we might as well close up and go to bed. The answer to this argument is obvious to anyone, but I could maintain that by shaving off a little time from each of several exposures we might get in an additional plate at the end.

However, Mr. Perrine kept on in his industrious way and proposed to expose for 10 hours over two nights on the region of Nova Persei. I believe that the time was cut to about seven hours by an oncoming storm, but on the resulting plate Perrine found the rapid expansion of the nebulosity about the nova, the first such motion to be discovered and one which holds the record for speed which will not be surpassed, inasmuch as it presumably represents the velocity of light.

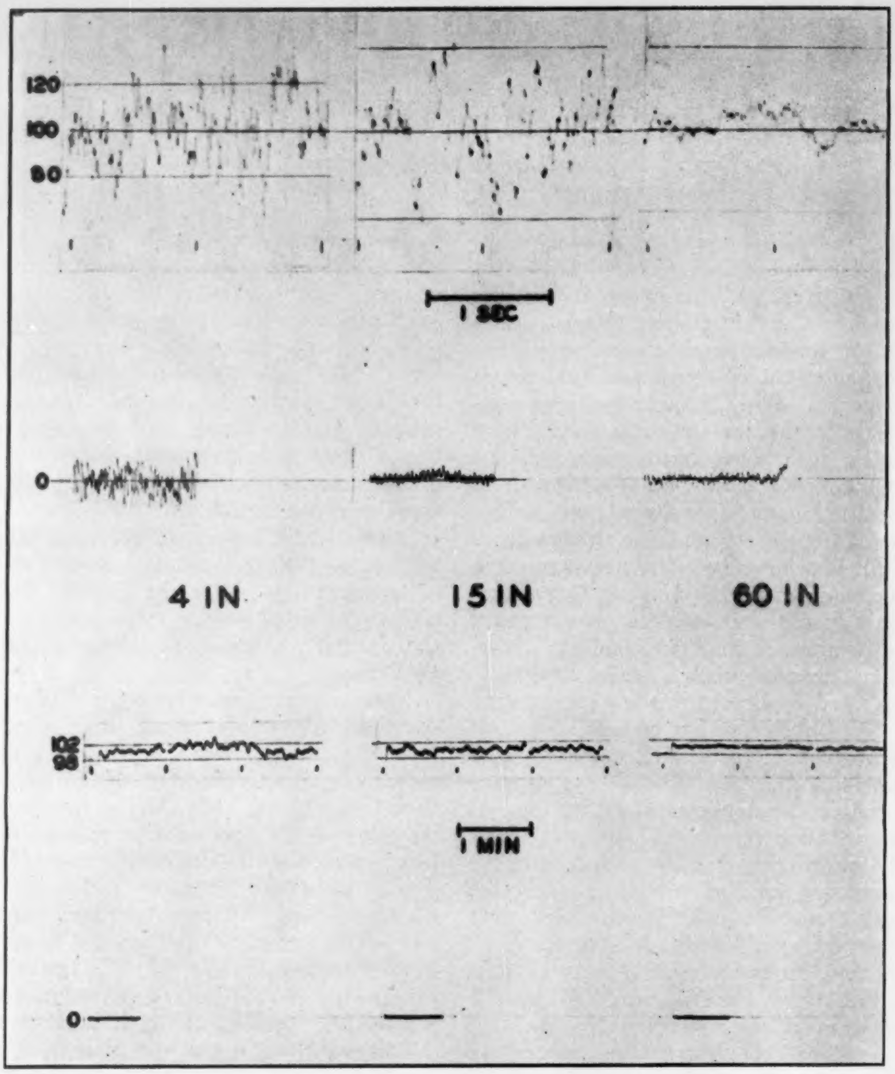
Although this episode might justly be considered to indicate the failure of the law of diminishing returns, in another sense the instinct of a sleepy assistant was sound. Perhaps he had a feeling for the failure of the reciprocity law in photography, governing the relation between intensity and exposure time. To secure constant density of the photographic image, the time must be increased in greater proportion as the intensity of the incident light is decreased. $It^p =$ *constant*. In this equation giving the relation between intensity I and exposure t, where p is less than unity, we have the exact formulation of one law of diminishing returns.

But quite apart from the photographic action for threshold images the limit for faint stars that can be photographed with any telescope is set by the brightness of the sky background. The exposures of seven or eight hours with the Crossley reflector of focal ratio f/6, made 40 years ago, are not practical now with faster modern plates. It takes an unusually dark sky to make it worth while to expose more than two hours with a reflector of focal ratio f/5. What we want is some region along the spectrum to act as a sort of window and allow us to photograph or see through to the stars and nebulae with a relatively reduced sky brightness. Such a window has been found and utilized by W. Baade with the 100-inch reflector. With red-sensitive plates and a filter transmitting the region 6000 A. to 6700 A. he has crashed through both the atmospheric and the interstellar dust clouds to record stars that cannot be reached with ordinary blue-sensitive plates. In fact, the prospect is that the beautiful and valuable photographs of the Ross *Atlas of the Milky Way* will have to be made all over again with a Schmidt telescope and red-sensitive plates.

Whereas, even without the failure of



The photoelectric cell and its containing tube, which is five inches in diameter.



Seeing with different apertures. In the upper part, short-period variations are shown, the largest variation on each side of the mean being about 40 per cent for a 4-inch aperture, 20 per cent for 15-inch, and five per cent for 60-inch. In the lower part, the circuit period of 15 seconds has smoothed out these variations to three or four per cent, one or two per cent, and one-half per cent or less, respectively. The zero lines show the "noise" in the dark of the circuit in each case; the greater noise for the 4-inch aperture was caused by the increased amplification necessary for the small aperture. Record by A. E. Whitford.

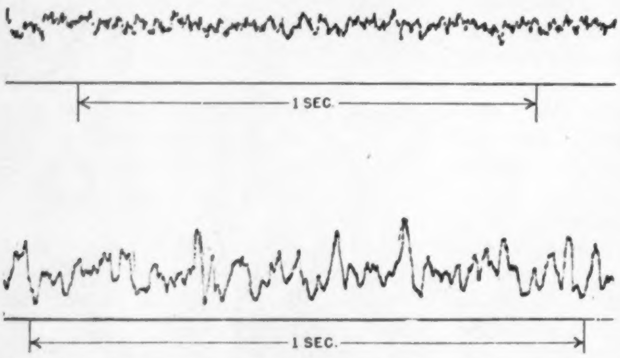
the reciprocity law, the fogging by the sky light would place a practical limit to the time of exposure of direct photographs, the same limitation does not apply in spectrum plates of moderately faint stars, where there is still plenty of contast between a star image and the sky background. It has been said that until recently the best method of getting the red or infrared spectrum of a star was simply "to wait." By postponing the work for a year or so, one could count on the development of a new plate which would be so much more sensitive in the long wave lengths that it seemed scarcely worth while to make the effort of long exposures with faster plates in prospect. Perhaps here is an instance of the law of increasing returns. Take things easy and some one else will make your work still easier. Seriously, he is wise indeed who can strike the proper balance between using the means at hand for a given problem and waiting for or developing new means for doing the same thing better or more easily.

At one time, when our science was being divided into the old astronomy and the new astrophysics, there were more than one of the old guard who used to say that in the astronomy of precision, as they called it, one could count upon an hour's results from an hour's work, whereas in astrophysics a large part of the experimenter's time was likely to be wasted. But even in well-established routine researches the law of diminishing returns came into force. Consider, for example, the weights assigned to star positions from different catalogues of meridian observations. In the Boss *General Catalogue,* the probable error of a position was considered to consist of two parts, the first being independent of the number of observations and the second diminishing with the number of observations according to the formula,

$$r^2 = r_0^2 + r_1^2/n$$

A glance at the tables in the *General Catalogue* shows that the weights almost never increase in proportion to the number of observations, and after a certain limit no greater weight is given no matter what the number of observations. We all probably treat our own measures of any kind in the same fashion. We repeat settings only to the point where additional ones are of little value because of the presence of errors which are not eliminated. This principle is applicable throughout physical science.

But it is not so much the fact that repeating the same work over and over leads to the law of diminishing returns as that some new method will revolutionize a whole field. When the late Dr. Frank Schlesinger took up the determination of parallaxes by photography with the long-focus Yerkes refractor, all previous parallaxes with the heliometer or meridian circle were soon superseded. Yet only last spring during my final visit with Dr. Schlesinger he remarked that the observational program for trigonometric parallaxes is about worked out. In 40 years the law of diminishing returns has taken hold again.



The twinkling of a star in good and bad seeing with a 6-inch telescope, recorded by A. E. Whitford; intensities are measured from the horizontal lines. Twinkling of a star in a small telescope can be observed visually by pointing the instrument at Sirius and watching the variations, not of the star, but of the bright field.

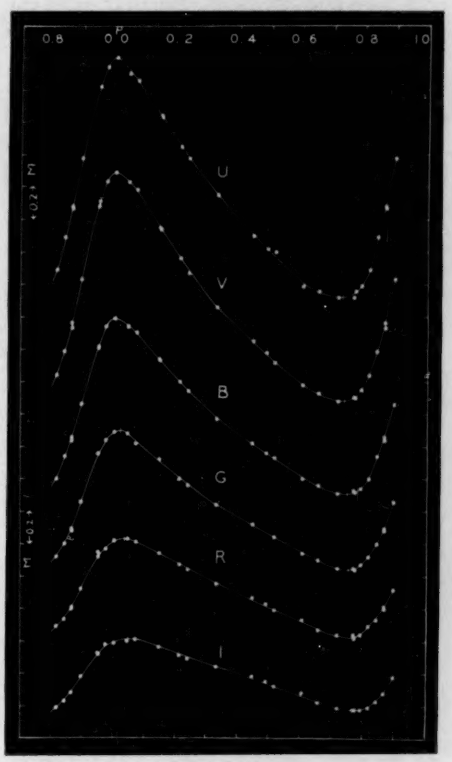
It was Simon Newcomb, the first president of the American Astronomical Society, who said: "To be revised, pulled to pieces, or superseded as science advances is the common fate of most astronomical work, even the best. It does not follow it has been done in vain; if good, it forms a foundation on which others will build. But not every investigator can look on with philosophic calm when he sees his work thus treated." Another president, Edward C. Pickering, while presiding over a session, once re-

marked in a discussion of some of the new methods of stellar photometry, that he had made a good many visual photometric observations himself (he had made more than a million) but he expected them all to be superseded. In his later years Pickering decided that the magnitudes of the fainter stars could best be determined by photography, and he diligently devised and carried on photographic programs. However, the visual work of Pickering still stands and will stand for a long time.

It is about time to devote some remarks to my own field of photometry. Over the years I have read a number of papers before the society, probably of diminishing value. The present may be an appropriate occasion to summarize some of them. I believe that at one time I reported that the sensitivity of the selenium photometer had been increased 100-fold; at another time, two magnitudes more. Then the photoelectric cell was reported as being two magnitudes better than the selenium cell. In a few years more perhaps another 1.5 magnitude was picked up with the photocell, and then the application of the thermionic amplifier was developed by A. E. Whitford, giving a four-fold increase or still another 1.5 magnitudes. Adding these reported improvements together we have $5 + 2 + 2 + 1.5 + 1.5 = 12$ magnitudes, or a factor of 63,000.

Strangely enough something has been left out. When F. C. Brown and I first mounted a selenium cell at the focus of a 12-inch refractor and pointed the telescope at Jupiter there was no detectable response whatever. Since then the faintest object which Whitford and I have measured with a photocell is a star of magnitude 16.1 with the 100-inch reflector. As the probable error of measurement was about 10 per cent, the limit of detection may fairly be called magnitude 18. From Jupiter at magnitude —2 to a star at +18 the change is 20 magnitudes. This advance is perhaps not so much a measure of the excellence of the latest developments as of the crudeness of the first attempts. Moreover, we must allow, say, five magnitudes for the difference between a 12-inch and a 100-inch telescope, leaving 15 magnitudes or a million-fold improvement in the apparatus itself. The limit of magnitude 16 was reached six or seven years ago, and the law of diminishing returns is working now. We can predict with confidence that the next 20 magnitudes will be harder to get.

When my friend and colleague, Jakob Kunz, passed on some five years ago, he was still optimistic about getting a more sensitive photoelectric surface of potassium hydride. In fact, he had actually produced cells which gave 10 times the response of some of the best cells on hand, but unfortunately they were not stable and the surfaces deteriorated in a few days or weeks. There are other blue-sensitive cells now available which give a response in micro-amperes per lumen considerably better than the best Kunz cells, but the commercial cells are usually not constructed with the extreme insulation needed for detecting small currents. It is the old story of what you want versus what you don't want, or the ratio of signal to noise, as they say in radio. Suffice it to say that there already exists the possibility of a photoelectric surface which, if deposited in the right way in the right cell or tube, will give greater effective sensitivity than anything so far available, but whether



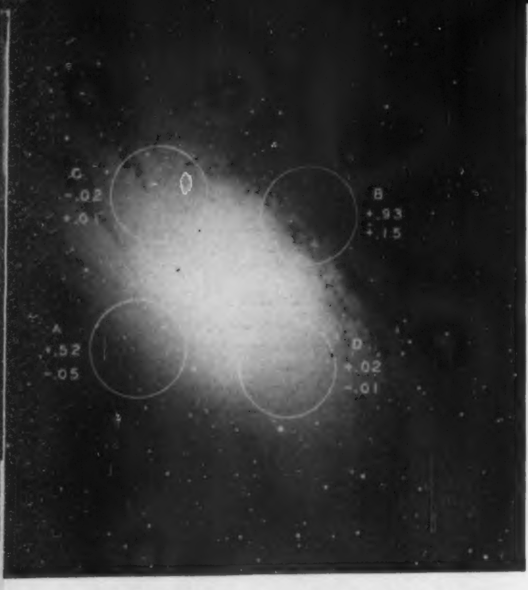
Light curves of Delta Cephei, well-known Cepheid variable star, in different colors, ranging from ultraviolet (3530 A.) to infrared (10300 A.).

the improvement will be as much as 10-fold is more than I can tell.

But how about the relative precision of measurement as the effective sensitivity of a stellar photometer was being increased? The answer is definite; while six decimal places in sensitivity were being picked up, a single decimal place in increased precision was scarcely achieved. I used to have a goal of a thousandth of a magnitude for the probable error of the magnitude of a star, but I have never reached it. However, that precision has been reached by Gerald Kron at the Lick Observatory. He has established the light curve of at least one variable star with normal magnitudes having a probable error of ±0.001 magnitude (see L. O. *Bulletin,* No. 499, 1939). As Kron has remarked to me, the limit of precision for bright stars observed with a small telescope, say up to 36 inches, is fixed not by the photocell, not by the amplifier, not even by the astronomer; it is fixed by the quality of the seeing. It took me a long time to learn that fact but it is true, and it has been demonstrated by Whitford at Madison and Mount Wilson. Using a photocell, a short-period amplifier, and an oscillograph to reveal the rapid fluctuations of a star at the focus of a telescope, he has recorded the difference between poor and good seeing. In poor seeing a star may vary four- or five-fold in intensity within 1/20 or 1/30 second, while in good seeing the maximum deviation may be not more than 10 or 15 per cent from the mean in the course of a whole second. With a galvanometer and circuit requiring 10 or 15 seconds to give a full deflection, these irregularities are to a great extent smoothed out, but under ordinary conditions with a 15-inch telescope, jumps of 0.5 to 1.0 per cent at the end of a long-period deflection are quite common. With the 60-inch or 100-inch telescope, the galvanometer is much steadier at the top of a deflection, and 0.1 per cent or 0.001 magnitude does not look so far out of reach.

An example of the futility of taking more than a reasonable number of measures of the same thing is furnished by the light curve of the well-known variable, Delta Cephei, which I determined visually some 35 years ago. About 7,000 individual settings were made on 72 nights, and I decided that nothing would be gained by further observations. This visual light curve may be compared with recent curves determined with the 60-inch reflector at Mount Wilson, using a photocell and filters which isolate six different regions of the spectrum. In about a third of the observing time which had been devoted to the visual work, it was possible to get light curves in the six colors, each one being superior to the visual light curve. The results furnish material for the theoretical study of this type of light variation. The new curves are uniformly smooth, showing no secondary fluctuations or humps. The amplitude of variation at 3530 A. is about 3½ times the amplitude at 10300 A. There is a retardation of phase for the longer wave lengths in the sense that the maxima and minima of light are later in the infrared than in the ultraviolet. The colors of the star at different phases are quite close to the colors of normal giants, ranging from $F4$ at maximum to $G2$ at minimum in good accordance with the changes in the spectrum.

During the past 10 years with my colleagues, C. M. Huffer and A. E. Whitford, I have spent a good deal of effort in determining color indices of stars with a photocell. These results have been criticized, principally by our-



Brightness and color in the Andromeda nebula. For each region the upper number gives the surface brightness and the lower number the color index, referred to the mean of C and D. Thus, the surface brightness of B is fainter than A by 0.93 — 0.52 or 0.41 magnitude, and the color index is 0.15 + 0.05 or 0.20 magnitude redder than A. Hence, the ratio of total absorption to selective absorption is 0.41/0.20 or 2.0. The positions of A and B are schematically portrayed on the diagram at the right below.

selves, because of the short base line or leverage furnished by the cell and filters used, the difference between the two spectral regions being little more than half the corresponding difference in the international system. The new six-color measures give so much more information about the radiation from a star that the old two-color measures are already out of date. Moreover, the extreme base line from 3530 A. to 10300 A. gives a scale some 7.5 times our former scale of color index. But here again, even while we are enjoying the power of the new method, the law of diminishing returns seems to have set in. The measures in the ultraviolet have been very useful in the application to extragalactic nebulae and in the determination of the law of interstellar absorption from reddened *B* stars, but experience has shown that for most stars a less extended base line will serve just as well. When a star's radiation is nearly a linear function of the reciprocal of the wave length, there is no advantage in a very long base line, because of the dispersion in the characteristics of stars of the same spectral class. Moreover, the ultraviolet measures are especially affected by hydrogen absorption in some stars and by variations in our own atmosphere. Therefore, it may be best to reduce the number of colors from, say, six to four, omitting the ultraviolet and the blue or green.

To utilize an intermediate base line for color index we have recently tried out a cell and two filters with effective wave lengths of 4200 A. and 7900 A. for a source at 10,000° K., giving a scale about four times the old photoelectric scale. This combination is good for the detection of small amounts of space reddening in early-type stars and is generally useful in measuring color indices of all stars. The red filter, however, transmits the radiation from what we believe to be one or more auroral lines in the neighborhood of 10000 A., certainly of wave length longer than 8500 A. When this cell is exposed to the sky alone through an infrared filter, the relative intensity near 10000 A., compared with a solar type star, is 10 times the intensity of any other part of the spectrum. A further study of this line or lines awaits the spectroscopists, but we know from its irregular behavior throughout the night that the radiation is atmospheric.

A communication from Dr. V. M. Slipher confirms the presence of this strong infrared radiation in the night sky, but he has not yet determined the wave length. A rough comparison of the observed relative galvanometer deflections along the spectrum of the sky with the deflection from a star of spectrum d*F*7 is as follows:

Wave length:	3530	4220	4880	5700	7190	10300
Deflections, d*F*7	8	8	10	8	8	8 mm
" sky	8	5	5	8	13	112 mm

Also, compared with other regions of the spectrum, the infrared has varied from summer to summer somewhat as follows:

1941	60
1942	80
1943	112

One is naturally suspicious of a connection with the sunspot cycle.

Even with this handicap of the sky radiation, the new color system which we call C_3 can be used on the brighter nebulae, and we have started, of course, with M31, the Andromeda nebula, just to see what would happen. It turns out that there is a difference in the color of the two sides of the nebula which, if interpreted as the effect of space reddening like that in the galaxy, gives at once the ratio of total to selective absorption. The new results may be summarized briefly. Let Apg be the total photographic absorption, E_1 the old color excess, E_3 the new, and E the international color excess, respectively. Then the different relations and the basis for each are as follows:

(1)	$A\text{pg}/E_3 = 2.01 \pm 0.10$ (p.e.)	Andromeda nebula
(2)	$E_3/E_1 = 3.86 \pm 0.13$	Reddened *B* stars
(3)	$A\text{pg}/E_1 = 7.8 \pm 0.5$	(1) × (2)
(4)	$E/E_1 = 1.90 \pm 0.12$	Seares, *A* stars
(5)	$A\text{pg}/E = 4.1 \pm 0.4$	(3)/(4)

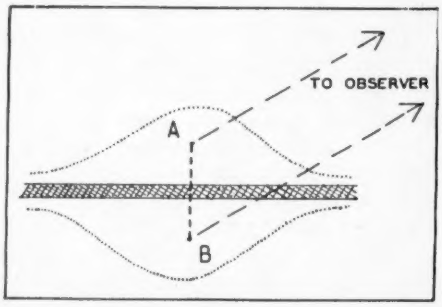
The weak step in the sequence is presumably in (4), the ratio of the international to the photoelectric scale. The result by Seares is from 52 *A*-type stars near the north pole, and is actually the ratio of the colors C/C_1 rather than the color excesses E/E_1. The latter ratio is probably higher than the former. Unfortunately nature has given us few *B* stars in the vicinity of the pole, and the interstellar absorption there is too small to give a reliable comparison of the two scales of space reddening.

It should be emphasized again that these results depend upon the assumption that selective absorption in the Andromeda nebula is the same as in the galaxy, also that the apparent surface brightness of the nebula for the regions measured would be symmetrical about the nucleus if there were no such absorption. However, the ratios in equations (3) and (5) look reasonable, and the value $A\text{pg}/E = 4.1$ will probably be welcomed by those who have claimed that a higher value of this ratio does not agree with the conclusions from star counts and other evidence in the galaxy.

Incidentally, if we assume that the absorption is caused by a thin layer near the median plane, these photoelectric results are in agreement with the view that the main dark lane of the nebula is on the near side, and therefore that the direction of rotation is such that the arms of the spiral are trailing.

I have included these examples from photometry not so much to illustrate the application of the law of diminishing returns as to show some efforts to combat that law. Perhaps the difference between the law of diminishing returns and the law of increasing returns is merely the difference between looking backward and looking forward. It has been well said that just as soon as a problem becomes easy it ceases to be research; if you are doing real research you are likely to be in difficulties most of the time. We have it from Bobby Jones that there is no easy shot in golf. If it is easy to get your ball on the green you should be aiming at the pin.

If I were to draw any moral from these remarks, it would be to remember that it takes only a slight improvement over what has gone before to open up entirely new opportunities, and when the law of diminishing returns seems to prevent us from doing something better, we can always try to do something different.



The effect of the median absorbing layer on the apparent brightnesses of different portions of a galaxy set obliquely to the line of sight. At A most of the stars are in front of the dark layer, while at B they are behind it. Therefore, B appears fainter and redder than A.

AMERICAN ASTRONOMERS REPORT

The Editors review some papers presented at the 71st meeting of the American Astronomical Society. Complete abstracts will appear in the Astronomical Journal.

Solar Cycle and Weather

CLOSE agreement has been found by Dr. Charles G. Abbot, secretary of the Smithsonian Institution, between measurements of calcium flocculi on the sun made daily by the monks at the Observatory del Ebro, Spain, and changes in the solar constant. The latter begin two days ahead of changes in the clouds of calcium gas seen on the sun in calcium spectroheliograms, and weather changes on the earth extend from three days before to 17 days after the occurrence of the solar changes with which they are correlated.

Dr. Abbot reported that for many locations it is easy to observe that the weather features tend to repeat at intervals of 273 months (nearly 23 years), and still more clearly at the double interval of 546 months which characterizes the complete cycle of solar constant changes. The short-interval day-to-day solar variations dominate the weather for many succeeding days. Dr. Abbot exhibited curves of these effects for all months of the year at Washington, Albany, Helena, and Ebro, Spain. A tentative trial of solar forecasting of temperature departures at Washington for 201 days, based jointly on Ebro and Smithsonian work, gave a correlation coefficient of 59 $\pm$ 3 per cent. In closing his remarks, Dr. Abbot predicted repetition of the past great Northwest droughts in 1975 and again in 2020.

Interstellar Reddening

A NUMBER of different substances are now known to be in the space between the stars. Photographs of star fields reveal the presence of dark clouds which absorb and redden the light of stars located behind them, while investigations with the spectroscope show that calcium, sodium, and several other elements and molecules are present.

In a note on the interstellar reddening in the region of the Orion nebula, Dr. W. W. Morgan, of Yerkes Observatory, discussed a broad spectral band located in the blue part of the spectrum and observed in a large number of stars being studied at Yerkes. It is in the region of 4430 angstroms, and is one of several broad spectral features discovered by Dr. Paul W. Merrill at Mount Wilson Observatory; these absorptions are as yet not attributed to any known terrestrial elements.

The intensity of the band in the blue appears to be closely connected with the amount of reddening the starlight undergoes during its passage through space. The band is not observed in the spectra of stars showing little or no reddening, while it becomes progressively stronger for those which are increasingly reddened.

There is, however, an exceptional case among the bright northern helium stars. It is Theta[1] Orionis, located in the Orion nebula. This star is definitely known to be considerably reddened by interstellar material, but the mysterious interstellar band in the blue is weak or absent. This evidence indicates that the material composing the Orion nebula is not like that which causes ordinary interstellar reddening. Dr. Morgan thinks it possible that the radiation from the hot stars within the nebula modifies the condition of the surrounding cloud of gas.

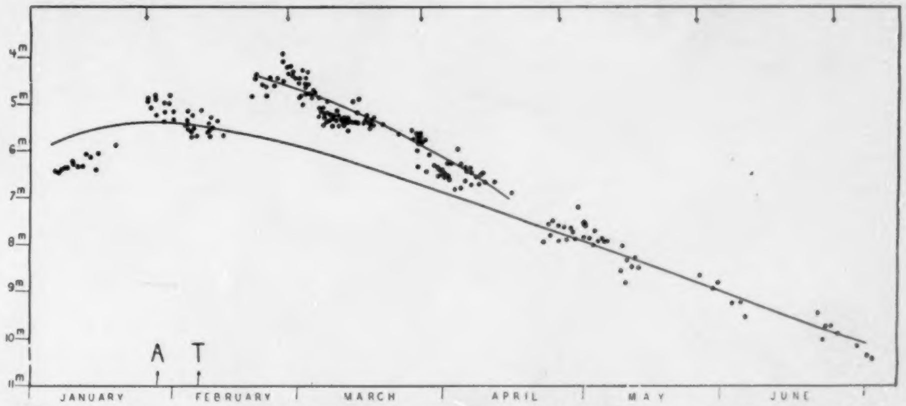
Light Curve of Whipple's Comet

A YEAR ago this comet was occupying the center of the celestial stage as it passed among the stars of the Big Dipper while also becoming bright enough to be watched easily from night to night. Dr. N. T. Bobrovnikoff, of Perkins Observatory, presented the light curve of this comet based on a total of 213 observations by 11 astronomers, including two in Russia. He stated that this comet (1942g) showed more remarkable fluctuations in brightness than any comet heretofore studied.

The observations made with different systems have been reduced to the Harvard photovisual system on the basis of Dr. Bobrovnikoff's observations with a 2½-inch finder. The light curve shows a periodic fluctuation in the brightness of the comet with a period of 30 days. The times of the maxima are shown in the accompanying diagram with arrows pointing downwards.

The time of the nearest approach to the earth is shown by the letter A, the time of perihelion passage by the letter T. The theoretical maximum of light of the comet should occur between these two dates, but the actual maximum came a month later. The lower curve shows the theoretical brightness on the basis of reflected light of the sun (inversely proportional to the square of distance from earth times square of distance from the sun). It fits the observations (except for periodic changes) in January and early in February, and again from April 15th to July 3rd. The upper curve shows the theoretical brightness on the basis of light inversely proportional to the square of the distance from the earth times the sixth power of the distance from the sun. It fits well in the interval for which the lower curve does not fit.

It is evident that about February 10th something happened to the comet to cause it to increase its brightness by 1.6 magnitudes; another outburst occurred at about February 23rd. Dr. Bobrovnikoff suggested the possibility that rather sudden outbursts of solar energy might account for this. A large sunspot group crossed the central meridian of the sun on February 11th. He did not believe there was any connection between the periodic fluctuations and the moon's phases, although the grouping of the observations is caused by lack of observations around the time of full moon each month.



The light curve of Comet Whipple 1942g, based on a total of 213 observations by 11 people, from January 4 to July 3, 1943. Arrows at the top indicate maxima of the 30-day periods of fluctuating brightness. The curve was compiled by Dr. Bobrovnikoff.

Sudden changes in the light curve have been found previously for Comets 1858VI, 1862III, and 1884I. However, Comet 1942g is unique in the combination of a sudden change with a distinctly periodic variation preserved throughout its period of observation of half a year. It is also remarkable in the closeness of the time of the nearest approach to the

earth (January 28th) and perihelion passage (February 6th).

AR Cassiopeiae

IN CONNECTION with discussions of relativity theory, most astronomically minded persons have heard how the theory successfully predicts the "advance of Mercury's perihelion." Thus, the point on Mercury's orbit where the planet is nearest to the sun is continually shifting, and rapidly enough to be easily observed. In the case of Venus, however, the orbit is so nearly circular that the perihelion point cannot be accurately determined.

If the perihelion point advances, aphelion must likewise move; the line joining them, the major axis of the orbital ellipse, when extended into space is called the *line of apsides*. The motion of perihelion can be described as a revolution of the line of apsides.

The star AR Cassiopeiae is a well-known spectroscopic binary, which Dr. Joel Stebbins showed in 1918 to be an eclipsing system, as well. The brighter star is of spectral type *B4*, contributing 97 per cent of the light of the system. Its diameter is some six times that of the sun and its luminosity, 250 suns. The fainter star appears to be of spectral type *A*, about twice the sun's diameter and seven times its brightness. The two stars revolve about their mutual center of gravity in a period of six days and their average separation is about one half the radius of the orbit of Mercury.

But long before the star was known to be an eclipsing binary, observations of changes in the radial velocity showed it to be double, and, in all, five sets of orbital elements have been derived, the earliest being from spectrograms made at Allegheny Observatory in 1908-9, and the latest at the Dominion Astrophysical Observatory, Victoria, B. C., in 1942-3. It is on this latest determination that Dr. R. M. Petrie reported to the American Astronomical Society.

Dr. Petrie finds the orbit of AR Cassiopeiae to be sufficiently elliptical that the direction, in space, of the major axis of the ellipse can be determined. It is found that the orbit is slowly turning in its own plane, the line of apsides describing one circuit in about 400 years. This is one of the longest apsidal periods to be determined spectroscopically.

Changeable Cepheid

EVERETT C. YOWELL, of Rutherfurd Observatory, Columbia University, told of a sudden change in the period of the Cepheid variable star, AR Herculis. It is of the 10th magnitude, a cluster-type Cepheid, its period recently determined, by astronomers at Budapest, as 11 hours and 17 minutes.

In his investigations, Mr. Yowell used photographs taken at Harvard from 1899 through 1941. They show that before 1925 the fluctuation in the brightness of the star took 11 hours, 16 minutes, and 51.0 seconds. Since 1925, however, the primary period has been 1.4 seconds shorter. A change in the secondary period of the star took place at the same time.

Cepheid variables are pulsating stars, as variations in the positions of the lines in their spectra show them to be expanding and contracting in rhythm with their light fluctuations. As a rule, they are very good timekeepers. Such a relatively sudden change in both the primary and secondary periods of AR Herculis can be explained only by some unknown physical change within the star itself.

Trapezium Stars

THE FOUR stars which form the famous Trapezium embedded in the Orion nebula have been studied by Drs. Otto Struve and John Titus, of Yerkes Observatory. They found the spectra of these stars difficult to measure because the bright, emission lines of the nebula itself were superimposed over the stellar spectrum in each case. The lines of the Trapezium stars were found to be displaced toward the red more than the emission lines of the Orion nebula itself.

The average velocity of recession of the Orion nebula, as determined from the positions of its spectral lines, is about 10 miles a second, but the Trapezium stars appear to be going away twice as fast. They have always been thought to be closely associated with the nebula, so it is surprising to find that they are apparently moving as a group through it: that they must some day be out of its neighborhood.

An alternative explanation was suggested by Dr. Struve, however, for he called attention to the probable large masses of these stars. As they are blue stars with very hot surfaces, they may shine brightly and still be of rather small size. The combination of large mass and small size is just what is required to produce an observable Einstein or relativity shift in the spectrum of a star. Previously, this shift has been measured for the white-dwarf companion of Sirius, where great density and small diameter produce a very noticeable relativity effect. As the Einstein shift is also to the red, it is not known now which explanation should be applied to the excess in the red shift of the Trapezium stars.

Rapidly Rotating Stars

FOR SOME years it has been known that among the stars of highest temperatures there occur a considerable number which rotate very rapidly on their axes. Our sun rotates once in about 25 days, while some of the so-called *helium* stars, such as Eta Ursae Majoris, rotate in as little as 15 hours.

Dr. W. W. Morgan, of Yerkes Observatory, reported that recently a number of cases of axial rotation more rapid than those considered earlier have been found, and it now appears that rotational speeds up to 400 or 500 kilometers per second are occasionally encountered. There is a definite tendency for the small, or dwarf, helium stars to rotate more rapidly than the giants. The actual period of rotation of some dwarf helium stars may be as short as six or seven hours. Such rapid rotation must distort a star to a shape far from the approximately spherical figure observed for our sun.

Radial Velocities of Faint A and K Stars

A REPORT of work in progress on the measurement of line-of-sight motions of some 1,000 stars fainter than the 10th magnitude and divided between spectral types *A* and *K* was presented by Dr. Frank K. Edmondson, of Kirkwood Observatory, Indiana University. The stars were selected, with the co-operation of Dr. A. N. Vyssotsky, from among the faint stars whose proper motions (angular motions across the face of the sky) have been measured at the Leander McCormick Observatory of the University of Virginia.

The spectrograms used for this investigation were taken with the 82-inch reflector of the McDonald Observatory in Texas, as part of the current plan of co-operation between the Universities of Chicago, Indiana, and Texas. Under this arrangement all three institutions take part in the maintenance and operation of the McDonald Observatory. The cost of operation is divided in proportion to the time used to secure the observations for the Yerkes and Indiana programs. Dr. Edmondson also used Mount Wilson spectra taken by Dr. S. A. Mitchell, director of the Leander Mc-

Cormick Observatory, during the summers of 1941 and 1943.

At the time of making his report, Dr. Edmondson had measured 74 *A*-type stars, based on two spectrograms each, and 136 *K*-type stars, most of them on one spectrogram. Each spectrum is measured direct and reversed on two different days, and the measures are independently reduced. Over 74,000 settings of the measuring machine are involved in the derivation of these 210 velocities.

No *A* star was found to have a radial velocity greater than 60 kilometers per second, but 10 *K* stars were found with higher velocities. The shift toward the red of the lines in the spectrum of one *K* star showed it to be moving away from the sun with a speed of about 250 kilometers per second, or 150 miles per second. Only about a half dozen stars are known to be moving faster than this.

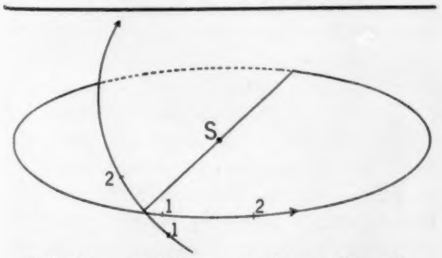
Atmospheric Refraction and Parallax Plates

IF ONE determines parallaxes of stars from a series of astrometric photographs, the observational errors can subsequently be established for the measurements of the single plates. In case the origin of these errors is purely accidental, smaller deviations are found more frequently than large ones and, moreover, errors with positive signs are about as numerous as negative ones. But if another pattern of errors is displayed in a particular series of measurements, the presence of systematic errors is usually indicated; these are due to a certain definite cause and follow a certain trend.

This latter situation, reported by Dr. Gustav Land, of Yale University Observatory, occurs not infrequently in parallax determinations, the individual errors for *one and the same night* being large throughout and displaying similar signs. These deviations are affected by what are called *night errors;* they are believed to originate in anomalies of atmospheric refraction.

In contrast to other refraction anomalies observed heretofore, Dr. Land as-

(*Continued on page 20*)



Relative positions of the earth (ellipse) and comet (open curve) at the time of discovery (1) and of perihelion (2). S represents the sun. The comet passed through the plane of the earth's orbit about December 22nd, only about five million miles from where the earth had been a month earlier.

Comet van Gent-Peltier

By G. Van Biesbroeck

Yerkes Observatory

THE MONTH of December, 1943, was marked by the presence of a fairly bright though short-lived comet which was first seen in the Southern Hemisphere by Dr. H. van Gent, of the Union Observatory, Johannesburg, South Africa. (See News Notes, January *Sky and Telescope.*)

Several days went by without further information about this newcomer which was located too far south for most astronomers on this side of the equator. However, on December 3rd, an observation was made, at the Lowell Observatory (Flagstaff, Ariz.) by H. L. Giclas, which showed that the object moved even faster than originally indicated. This made it probable that the distance from the earth was decreasing, but the information did not suffice to predict the future course, although it was to be foreseen that the comet would soon move into the evening sky.

On December 18th, the central bureau at Harvard received a telegram from the star comet-hunter in this country, Leslie C. Peltier, of Delphos, Ohio, reporting his discovery of a 7th-magnitude comet in Aquarius, right ascension $23^h\ 20^m$, declination —16°, moving slowly westward. When I obtained an accurate position the next night, it appeared that the motion was fairly rapid and in a northwesterly direction. It was therefore probable that Peltier's catch was none other than the earlier found southern comet which was now sweeping northward. This was confirmed when on December 22nd the following elements computed by Dr. J. Jackson, of the Cape Observatory, were radioed:

Perihelion time	1944, Jan. 12.283 U.T.
Node to perihelion	33° 9′
Node	57° 50′
Inclination	136° 11′
Perihelion distance	0.8738 A.U.

The comet had evidently been followed continuously by the southern observatories, thus giving the necessary data for determining its course in the solar system. The diagram shows the relation of the earth's and the comet's positions. Minimum distance between the two bodies occurred December 9th, when the separation was less than a quarter of the sun's distance. The comet must have been near naked-eye visibility shortly after that time, but soon after Peltier's independent discovery the rapidly increasing distance from the earth caused fading of the apparent brightness, even though the comet's intrinsic light was increasing as it approached perihelion. By the end of December the brightness was back to that of discovery in November, about 9th magnitude.

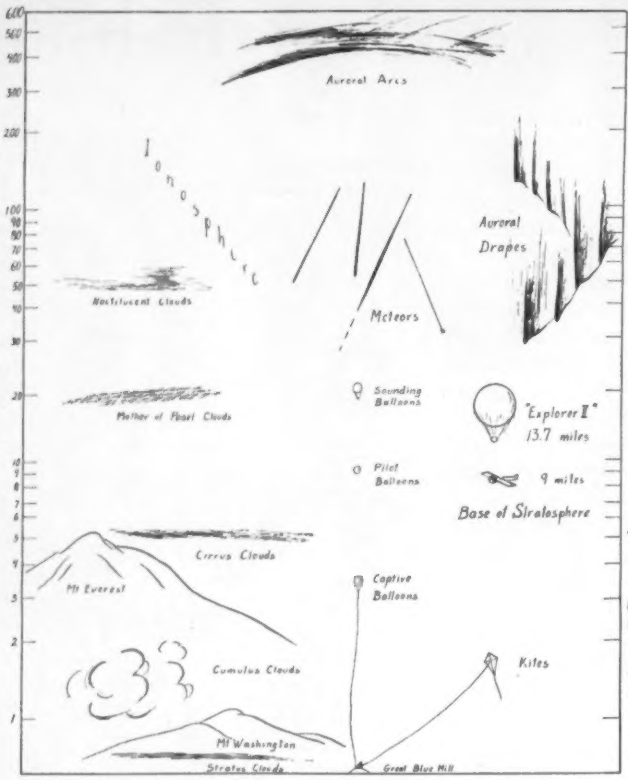
The newcomer did not display much physical activity: when first seen here on December 19th, it showed a sharp nucleus centered in a spherical coma six minutes in diameter, which corresponds to 10 times the earth's diameter. A faint tail was suspected. On December 24th, a 20-minute exposure with the 24-inch reflector at Williams Bay showed the slender tail reaching to the edge of the plate one degree from the nucleus and probably extending well beyond that in space. Finding difficulty in reproducing it photographically, I made the charcoal drawing shown here, which illustrates the general appearance. No spectroscopic data about the comet have become available. With large telescopes the comet will presumably be followed for several months, but it has now become too faint to be of interest for amateur telescopes. It remains an evening object until conjunction with the sun in the middle of February.

A charcoal drawing of the comet made by Dr. Van Biesbroeck.

THIS EARTH

By William H. Barton, J

Although we cannot view the planet earth fro deep inside it, our knowledge of this earth of sive, as related here and in the Hayden Plan



Atmospheric phenomena occur at various heights, many of them far above the level of man's highest flight. Note that the vertical scale is logarithmic.

As planets go, we do not rate too high. In fact, we are about average. There are four larger and four smaller (not counting asteroids). We line up similarly in regard to mass. However, we have a personal interest in the earth that can hardly be denied, and must therefore be pardoned if we devote an entire article to it, then dispose of eight neighbors in another story.

This earth of ours is a globe, nearly 8,000 miles in diameter. The statement is probably not a startling one, but suppose for the moment you were left to your own devices, could you back up these facts with evidence?

Not every one, even today, will agree on the roundness of the earth. The common belief, up to the time Magellan sailed around the world, was that it was flat, and in one's everyday experience there is little to disprove that idea. All down through the ages, however, well-informed people believed the earth to be spherical. The maritime Greeks knew from their star study that the earth was round and the Phoenician mariners knew it.

Anyone who has been at sea or who has spent time at the seashore knows what is meant by a ship "hull down." The first evidence of an approaching vessel will be the sight of its mast tip or the tops of the funnels. Then more of the superstructure appears, and last, the hull. This could occur only on a spherical planet.

Perhaps it sounds silly to ask — but why do they build lighthouses high? The answer is that they can be seen at greater distances, which is an admission that the earth is round. If the earth were flat, a low beacon could be seen at as great a distance as a high one — but not on a spherical earth. The beam of light from the lamp goes outward in straight lines. The higher the source, the farther some beams will travel before they strike the earth. Beyond that point the light is invisible from the surface. This limiting distance equals in miles the square root of three halves of the height in feet. That is, a lighthouse 67 feet high is visible 10 miles.

OUR EARTHLY FLIGHT

Our Earth is like a transport plane,
That carries wealth surpassing gold.
It traffics not for paltry gain:
Its cargoes are not bought nor sold.

It holds its course around the sun:
Nor rolls, nor banks, nor stalls, nor spins.
Its yearly flight is never done;
When winter ends, the spring begins.

At eighteen-miles-per-second speed
Without an instrument in sight,
No stick to hold, no maps to read,
It travels on by day and night.

It bears a load of human freight;
From birth to death, men come and go.
They live and love, they toil and hate,
For good or ill, for weal or woe.

A billion walk its crowded ways:
And billions sleep beneath its sod.
But souls are safe through stormy days:
The unseen Pilot's name is God.

W. CARL RUFUS

In actual practice on board ship, the height of the observer's eye increases this distance considerably.

No doubt many readers have seen the earth's shadow on the moon at the time of a lunar eclipse. It is always a circular shadow. The only geometrical solid that always has a circular shadow is a sphere.

All three of these proofs are within the experience of most people, and in the same way we can encourage you to measure the earth as it was first measured 2,200 years ago by Eratosthenes.

This was the first determination of the size of the earth. He knew that at Syene on June 21st the sun shone at noon down a deep well. Therefore the sun was in the zenith, and Syene was on the Tropic of Cancer. He also knew that at Alexandria, 500 miles due north, the shadow of an obelisk indicated the sun to be 7½ degrees south of the zenith. Therefore, if 500 miles over the curved surface of the earth changed the sun's apparent direction by 7½ degrees, it would require 24,000 miles to change it 360 degrees.

In the same way, if you measure the noon shadow of the sun at two places on the same date, not necessarily in the same year (or can enlist the aid of a confederate), you can find the angular difference between the locations. You must also know how many miles one is north of the other, but the two places of your experiment need not be on a north-south line. By working the problem as above, you, too, can measure this earth of ours. Don't expect too accurate a result, as your measures will necessarily be rough.

The earth, strictly speaking, is not a true sphere. Sir Isaac Newton made an early study of the true shape of the earth. He discussed the matter theoretically, and reasoned that the spinning of the earth would tend to flatten it toward the polar regions. He assumed that the earth was a uniform mass and was once in a fluid state. His value for the flattening, 1/230, has since been corrected to nearly 1/300. The values in the tables of constants in our *American Ephemeris* are

Polar radius: 3949.99 statute miles
Equatorial radius: 3963.34 statute miles.

The difference is only 13.35 miles, but this difference creates some peculiar effects.

OF OURS

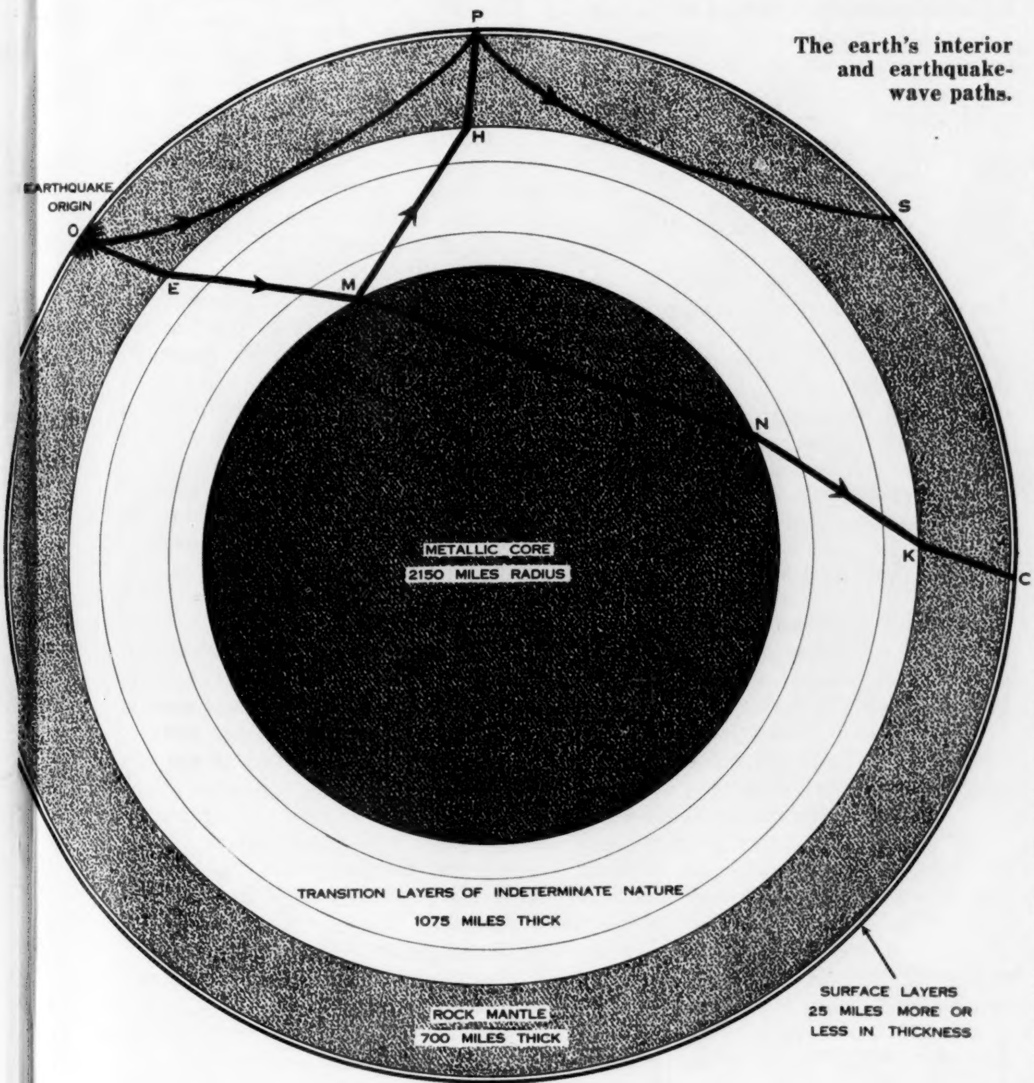
ARTON, JR.

earth from space, nor plunge
earth of ours is quite exten-
den Planetarium this month.

We usually speak of going "up" to the north pole and "down" to the equator. We should say "down" to the north pole (we do say "down" to the south pole, but for other reasons) and "up" to the equator. By the same token the Mississippi runs "uphill."

The gravitational pull of the earth, or of any other body, for that matter, decreases as we move farther away from its center. Therefore, the surface gravity along the equator is less than at the poles. That is, bodies weigh less there — at least when weighed on a spring balance. They are lighter, too, for another reason. The rotation of the earth creates centrifugal force. Bodies tend to fly off the spinning earth. If it were turning fast enough they would fly away, but at its present speed they are merely lightened by a tiny amount. If you weigh 200 pounds at the north pole, you will weigh about a pound less at the equator. Credit about five ounces of this to the fact that you are 13 miles farther from the center and the other 11 to the earth's rotation.

The blanket of gases that we call the atmosphere has many effects on the earth. From some points of view the atmosphere is a nuisance, from others a necessity. Any way we care to view it, we are faced with the same fact. It is there, and we must make the best of it. That blanket of air supports life on the earth, and makes it impossible to see the stars in the daytime. It keeps out certain death-dealing radiation from the sun, and bends the rays of light from the stars so that we have to correct even the crude observations of the navigator. It retains the earth's heat during the night hours, and at times its lower levels get into such violent motion that great destruction is the result. It protects us from a constant rain of meteoric material, and then develops such high electric charges that it strikes death to the earth's inhabitants. The atmosphere brings us the aurora, one of nature's most beautiful phenomena, rainbows, the blue sky, sunset colors, the twinkling of the stars, and meteor showers. We have climbed through the atmosphere less than 14 miles, and all we know about what is above that has come through remote-control or indirect studies.



The earth's interior and earthquake-wave paths.

Nor have we penetrated the solid portion of the earth very far, only two or three miles, in fact. We do know a great deal about the interior, however. Studies of the variation of gravity, of the intensity and direction of the earth's magnetic field, and of the propagation of earthquake waves have contributed a great deal to our knowledge of this earth of ours.

There used to be an old belief about the core of the earth being a molten mass. Did it not flow out through volcanoes at the least disturbance? We now recognize that the earth has a core of iron, or of iron and nickel, highly compressed to a density of 10 or 12 times that of water, extending to about half the radius. Then there is a layer of about average density, 5.5, perhaps also iron, or an iron-stone mixture. This intermediate layer is over 1,000 miles thick and is overlaid with a rocky layer, perhaps 700 miles in thickness and of density about 4.3. The outer crust is only 25 miles or so in thickness and seems to float on the lower strata. Our earth's surface is so unstable that it moves around somewhat. Over long periods a considerable shifting may have occurred in the land masses.

The origin of the earth is largely a matter of speculation. Undoubtedly, the material of which the earth is composed came from the sun, as did that of the other planets in our solar system. Perhaps these nine bodies in our family of worlds were cast off from the sun by some cataclysm, a collision, a near-collision, or similar event. The steps by which we reached our present state of affairs are rather obscure. Cooling, shrinkage, and other slow evolutionary processes, some of which are no doubt still operating, changed a hot, molten mass of material to the habitable planet we know today.

Tiny man on the earth's surface — it would take 25 million people holding hands to encircle the equator — has measured its diameter without digging a hole through it. He has weighed this planet without putting it on a scale, and found its mass to be 6,600,000,000,000,000,000,000 tons. He uses its speed of rotation to keep his time, and can even detect variations in that rotation. He can calculate its speed around the sun, and uses its orbital motion for a calendar. From this little whirling globe, despite the disturbing atmosphere, he can measure the constitution and temperatures, the distances, the motions, and the ages of the remote stars and planets.

NEWS NOTES

By Dorrit Hoffleit

OUR GALAXY

At an annual meeting of the Society of the Sigma Xi held recently in Chicago, the address by President Harlow Shapley revealed the results of new extensive investigations on the dimensions of the Milky Way system. Previous results are confirmed, indicating a nearly spherical haze of stars surrounding the familiar, flattened ellipsoidal system where the greatest numbers of stars are concentrated.

The extension of the "haze," over 100,000 light-years, is determined largely from studies of globular clusters, especially those situated in transparent regions of space. This transparency is determined from the observed frequencies of the more distant external galaxies in the areas surrounding the globular clusters. Where there is much obscuration by dust clouds and other material within our own system, the faint distant galaxies either cannot shine through or are dimmed and reddened in a characteristic manner. The distances of the clusters are determined from the luminosities of variable stars or other very bright objects whose real brightnesses can be assumed equal to those of stars relatively near the sun having the same physical characteristics.

The new studies do not change the general picture of our galactic system. The sun is still found to be located some 30,000 light-years from the center. The average brightness of the globular star clusters is found to be over 100,000 times the sun's. When compared with the globular clusters in our neighboring galaxy, the Andromeda nebula, however, our clusters appear to be systematically brighter, if the accepted distance to the Andromeda nebula is correct. More probably the new estimates imply that the distance of the Andromeda nebula has been considerably underestimated.

TRAINED METEORS

In a paper published in 1941 but received only recently, V. V. Fedynsky, at Tadjik Observatory, U.S.S.R., has analyzed 41 luminous meteor trains observed in 1934-38. The changing shapes and drifts of the trains reveal facts about turbulence and currents in the earth's atmosphere at altitudes (of about 50 miles) which are inaccessible to ordinary meteorological study.

The most frequent velocity for the train drifts is of the order of 70 meters a second, although a few velocities as high as five times that amount were found. The average speeds before midnight were much higher than after, groups with velocities of 130 and 230 meters a second (nearly 300 and 500 miles per hour) being most frequent. The directions of drift are disorderly, but easterly drifts prevailed.

Diffusion, or widening of the trains, was also studied. For 10 trains for which such measurements were available, the rate of expansion varied from 2.4 to 49.7 meters per second, the most representative mean being 7.2 meters a second. These figures are lower limits, since the edges of the trains fade out so that they cannot be easily measured.

The diameters of the trains measure several hundreds of yards, depending on the magnitude of the meteor. This relation between brightness and train-diameter is satisfactorily accounted for by the theory of phosphorescence or afterglow.

In another paper, Astapowitsch and Fedynsky describe the trains of two fireballs (observed in 1937, published in 1940, received 1943), the train-drift velocities amounting to as much as 340 to 370 miles an hour.

R. A. McIntosh, of the New Zealand Astronomical Society, in a paper, "The Physical Characteristics of Meteors," finds from a study of over 12,000 observations that only 126 out of every 1,000 visual meteors leave trains. Those that do are generally the brighter meteors. The average magnitude of "trained meteors" is 0.9 compared with 3.2 for the untrained.

"TIME FOR SCIENCE"

A weekly radio series discussing the effects of the great scientific developments growing out of war research upon everyday living is being presented each Saturday evening from 7:30 to 8 p.m. over station WHAM, in Rochester. Sponsored by the University of Rochester in co-operation with *Time* magazine and WHAM, the programs will be directed by Dr. Gerald Wendt, science editor with *Time,* and author of *Science for the World of Tomorrow.* At each "Time for Science" broadcast, a leading American scientist or social thinker will discuss how scientific advances will affect industry and business, and the daily lives of people in every walk of life.

MEXICAN ECLIPSE EXPEDITION

The sun, as seen from parts of Peru and Brazil, was scheduled to be totally eclipsed by the moon on January 25th. While United States astronomers were not planning to go to see the eclipse, wide-awake Mexican astronomers and government officials organized an expedition to Cajamarca, Peru, on the initiative of Governor Gonzalo Bautista of Puebla, and under the sponsorship of the Mexican federal government, the state of Puebla, and the University of Mexico. The party is headed by Dr. Joaquin Gallo, director of the Mexican National Observatory at Tacubaya. Dr. Gallo is an experienced observer who attended eclipse expeditions to Spain in 1905 and to northern Mexico in 1922. Other members of this expedition are Drs. Luis Erro and Carlos Graef, director and assistant director, respectively, of the new Astrophysical Observatory at Tonanzintla.

FIFTY YEARS OF PROGRESS IN ASTRONOMY

In a paper with this title in a recent issue of ***Popular Astronomy,*** Dr. Otto Struve, director of Yerkes Observatory, gives a general survey uncovering the trends in astronomy from 1893 to 1943. The article serves as an introduction to a series of papers on various aspects of astronomical development being prepared in commemoration of 50 years of ***Popular Astronomy.***

Dr. Struve mentions not only the highlights, but looks also "into the dark recesses of incompetence and failure." Invaluable as the gain has been from the ascendancy of astronomical photography, the author yet deplores the decline in visual observing, which is indispensable to numerous problems. Barnard's discovery of the fifth satellite of Jupiter is cited as an example of an object that would probably never have been found photographically. Double-star astronomy has certainly suffered from the neglect of visual observations. Other problems also require such methods, for instance, the verification of faintly luminous interstellar clouds, having a color not readily photographed, that were reported by Father Hagen years ago.

Among other topics discussed is the relative decline in the use of refractors as compared with large reflectors — except among parallax observers — in spite of the fact that "a large mirror acts like a pancake," becoming easily distorted with changes in pressure at the supports, and tending to become astigmatic with temperature changes.

The decentralization in observatories, with greater tendency toward individual research, has been a significant trend. Formerly, the specific interest of the director of an observatory largely dominated the institution's program. The modern tendency toward greater recognition of the interests of the individual workers has been accompanied by a decline in "internationalism."

The stimulating introduction that Dr. Struve has given makes us look forward to the further contributions to the promised series of papers.

Amateur Astronomers

SEASONAL CHANGES ON MARS

By Latimer J. Wilson

South is at the top in these photos of Mars.

THESE three photographs of Mars were taken through a 12-inch reflector. The right and left disks were secured on December 8th, at $3^h\ 46^m$ (mean) U. T. The central image was taken on July 22, 1939, at $7^h\ 18^m$ U. T. Seeing conditions were somewhat better on this earlier date, and Mars was about 14,645,066 miles nearer to us in 1939.

Note the south polar cap at the top of the central image. It was rapidly diminishing in size since the season in the southern hemisphere corresponded to earth's mid-April. The Martian heliocentric longitude on July 22, 1939, was 210°.7, which, according to Pickering's Martian calendar, was Martian date October 30 (northern hemisphere) or October 23, terrestrial date. The seasons on Mars are about twice as long as those on the earth. There, in the middle of the southern spring, the dark markings in the southern hemisphere were becoming darker, indicating perhaps the growth of some kind of vegetation. A notable extension of the dark tip extending downward from the dark area, in longitude 236°.6, which was the longitude of the central meridian at that instant, was a new feature appearing in 1939 for the first time.

On December 8, 1943, almost an exactly opposite season prevailed in the Martian southern hemisphere. The planet's heliocentric longitude was 345°.5, the Martian date for the northern hemisphere being, therefore, February 29. This corresponded to March 5, terrestrial date, or the southern season of September 5. The Martian southern hemisphere was therefore passing from late summer into autumn, and no distinct south polar cap could be seen although the inclination of the pole toward the earth was about the same as that of July 22, 1939. Also, only slight indication of the new dark area of 1939 was suggested by the extension of the tip of the central dark area about five degrees farther toward the equator than normal. The portion of the dark region extending toward the left has been named Cimmerium, and the northern tip is called Synus Gomer.

THIS MONTH'S LECTURES

Cincinnati: Dr. Frank K. Edmondson, director of Kirkwood Observatory of Indiana University, will lecture at the meeting of the Cincinnati Astronomical Association on Friday, February 11th, at 8:00 p.m. at the University of Cincinnati Observatory. The talk on "The Milky Way" will be illustrated with slides.

Cleveland: On February 25th, Dr. Bart J. Bok, of Harvard College Observatory, will address the Cleveland Astronomical Society on "Astronomy and the War." The meeting is at 8 o'clock at the Warner and Swasey Observatory, East Cleveland.

New York City: "New Horizons in Astronomy" will be discussed by Dr. Jan Schilt, of Columbia University's Rutherfurd Observatory, before the Amateur Astronomers Association on February 2nd. The meeting, open to the public, will be held at the American Museum of Natural History at 8 o'clock. On February 16th, under the guidance of Miss Hazel Boyd, the regular monthly observation meeting will be held.

ASTRONOMICAL ANECDOTES

(*Continued from page 4*)

tributions in optical methods (an example is in the *Journal* of the Optical Society of America for November, 1939), and some of the auxiliary equipment of the observatory has been designed by him, along somewhat novel lines. The new observatory has its work pretty well laid out, removing some of the lopsidedness of our astrophysical statistics, heretofore largely based upon the regions of the sky within reach of the large reflectors of the Northern Hemisphere. Also in the Southern Hemisphere is the 60-inch Rockefeller reflector of the Boyden station of Harvard College Observatory in South Africa; soon after the war (it is hoped) the 74-inch reflector of the Radcliffe Observatory will also be in operation in South Africa.

I hope within a few years to be able to detail the story of an even larger reflector now for many years delayed — such instances are frequent in the history of astronomy. Piazzi Smyth is said to have been very grateful to find a large telescope finished on the very day the makers had promised it; only the year of the instrument's completion was wrong!

At Dunsink, about four miles from Dublin, the Observatory of Trinity College was located in 1783. The first director was the Rev. Henry Ussher, who displayed great energy and ingenuity, and asked Jesse Ramsden to build a mural circle of 10 feet diameter. This was sometime before June, 1785. Ramsden set to work, and abandoned the idea of a 10-foot circle; he tried a 9-foot circle, and abandoned that, too. He settled on an 8-foot circle, which was at last completed, but not for some time, and not by him.

Ussher died in 1790 and was succeeded by the Rev. John Brinkley of Cambridge. In 1792, Ramsden promised the instrument within the year. In 1800, Ramsden died, and the circle was still undelivered. Berge succeeded Ramsden, and in 1804 promised delivery in August of that year. Finally, in 1808, at least 23 years after it had been ordered, the instrument was set up at Dunsink.

They had tough luck at Dunsink; in 1793 they sent two clocks out to be repaired. The last record of them was in 1816, when they were still being repaired. In 1826, Brinkley became the Bishop of Cloyne, and retired completely from astronomy; he served his church faithfully until his death in 1835.

One of Brinkley's monuments was his *Elements of Plane Astronomy,* which was revised by several, including Francis Brunnow, who arrived at Dunsink in 1865 as Astronomer Royal for Ireland, after having been the first director of the (then) Detroit Observatory of the University of Michigan, at Ann Arbor. He was there from 1855 to 1859, when he went to the Dudley Observatory in Albany. He had returned to Ann Arbor briefly in 1863, leaving soon when his father-in-law, President Tappan of the university, was removed. He was succeeded by James Craig Watson, who enrolled in the university in 1853 at the age of 15 and became director of the observatory at the age of 25.

It is said that on one occasion some gentlemen from the legislature visited the observatory and saw Brunnow lecturing to only one student. When he was asked about the propriety of conducting lectures for a single student, Brunnow simply said, "But that one student is Watson." I'll give you more about Brunnow and Watson, they deserve attention.

R. K. M.

BOOKS AND THE SKY

SOLAR RELATIONS TO WEATHER

Henry Helm Clayton. Clayton Weather Service, Canton, Mass., 1943. Vol. I, 105 pages; Vol. II, 439 pages. $3.00 each.

OF PRIMARY importance to meteorology, in fact, to all life, is solar radiation. This incoming radiation to the earth is termed insolation by the meteorologist. Mr. Clayton, in the first volume of his interesting book, attacks the problem of changes in the insolation, which in turn determine the movement of air masses, the principal data upon which all modern forecasting is based.

The first volume, which is itself a summary of Volume II, consists of six chapters and a special supplement inserted at the front of the book. In the supplement, "The Cold Waves of the Winter of 1942-43 in Relation to Solar Activity," the author correlates changes in the maximum and minimum of sunspots and solar faculae with changes in insolation and the cold waves which developed in the central area of North America during the abovementioned period. At the end of the supplement a table gives the dates of observation of large sunspot and faculae groups, the predicted times of the occurrence of cold waves, and the time at which the cold waves were experienced. The results show that every cold wave in the Middle West, except that of December 12th, is satisfactorily accounted for in the sunspot and faculae observations.

Chapter I, "The Yearly and Daily Cycles," serves to introduce one to the variations that take place in temperature and pressure due to the rotation and revolution of the earth. The information is for the most part a discussion of ordinary meteorological terms and facts, which are shown later to fluctuate in effect and intensity with increasing and decreasing solar activity.

In Chapter II, "Solar Variability and Weather," the effect of increased sunspot activity on the mean distribution of pressure centers in the atmosphere is considered. Mr. Clayton's researches show that at a time of increased intensity of solar activity, the means of the areas of excess pressure are displaced northward, changing the distribution of pressure and influencing the movement of the air masses which give us our weather. A set of charts reveals that bands of excess storm activity are located in southern Canada at sunspot minimum and move southward reaching the middle latitudes at sunspot maximum, continuing southward into the low latitudes by the next minimum, at which time a new band appears in Canada. The latter part of this chapter is devoted to variations in the solar constant and their influence on changes in temperature and pressure.

"Solar Cycles and Weather Cycles" presents various terrestrial cycles that show a close correlation with the period of solar rotation and sunspot frequency. Information of this kind is of extreme importance if short- and long-range forecasts are to be accurately made.

The principles of forecasting, utilizing the methods outlined by the author, are presented in the fourth chapter. Examples of forecasts in pressure, temperature, and rainfall, using solar changes in faculae and sunspots together with weather cycles are given. Successful individual temperature predictions as many as four to five days in advance for New York form only one of the many applications of the method.

The succeeding chapter contains examples of apparent relations between various solar cycles, weather cycles, and life cycles. The discussion is approached from the weather point of view.

A suggestion as to a possible cause of sunspots is presented in the concluding chapter, "The Hypothesis of the Planetary Cause of Sunspots." The author states that he considers it only as a working hypothesis, and that "the acceptance of this hypothesis in no way affects the validity of the matter presented in previous chapters which is based entirely on observational data."

The second volume is a collection of brochures, all of which, with the exception of four, cover the researches of Mr. Clayton in weather phenomena. The extent of time and experience which has been put into these researches is evident when one observes the date of the first brochure, May, 1884.

Solar Relations to Weather are two volumes containing a wealth of meteorological information worthy of the attention of everyone interested in weather and long-range forecasting. The results of some of the forecasts in these books, based upon the information of an insufficient number of stations, promises great

NEW BOOKS RECEIVED

THE OBSERVER'S HANDBOOK FOR 1944, *Royal Astronomical Society of Canada*, 198 College St., Toronto, 1944. 80 pages. 25 cents.

In its 1944 edition, the *Observer's Handbook* contains the same invaluable current material that has been included in previous years.

For those amateurs who are not familiar with the publication, the book includes among other things, tables of sunrise and sunset times; twilight, and moonrise and moonset; discussion of the planets in 1944, with maps; a list of phenomena for each month; several lists of observable objects of various kinds. Each year one is amazed anew at the information here available for 25 cents.

SCIENCE AT WAR, *George W. Gray*, 1943, *Harper*. 296 pages. $3.00.

How physics, electronics, chemistry, medicine, are contributing to the war effort is told by this well-known author.

ELECTRONIC PHYSICS, *Hector, Lein* and *Scouten*, 1943, *Blakiston*. 355 pages. $3.75.

An elementary text on modern physics, with many diagrams, and questions and experimental problems at the close of each chapter.

TOMORROW WE FLY, *William B. Stout* and *Franklin M. Reck*, 1943, *Thomas Y. Crowell*. 160 pages. $2.00.

The place of aircraft in the world of tomorrow is told in this fascinating book, which emphasizes the coming remarkable development of the helicopter.

things in long-range forecasting if and when enough well-equipped stations are available for service.

CPL. ROBERT E. COX
Weather Wing, Army Air Forces

KNOWING THE WEATHER

T. Morris Longstreth. The Macmillan Company, New York, 1943. 150 pages. $1.69.

TO WRITE in an easy, graphic style a small book on a big subject, allotting to each of its phases a single chapter of three to five pages, avoiding technical and mathematical terms and difficult explanations while at the same time conveying a very fair idea of the whole to a reader who has no time for textbooks — this task requires not a little skill. The author, in setting out "to present the fundamentals of weather, the primal simplicities every flier must know," has given in 23 chapters, a clear, elementary account of the general circulation of the atmosphere and the movement of air masses; also, as applying to North America, of clouds as forecasters, of winds, hygrometers, temperature and pressure, of hurricanes, tornadoes, and so forth. Mr. Longstreth is not only a veteran meteorologist, he is also a writer, and his enthusiasm for the new science finds expression in a natural, fluent prose, carrying the reader with it. In places, this prose is all but transformed into poetry. The passage on the cumulonimbus (page 43) may be compared with Herman Melville's famous description of the Pacific, or Ruskin's of Venice.

This little volume is not for the young meteorologist, who will disdain it; it is primarily for the layman, though it will also appeal to the amateur. The photographs are of the best; there is an index, a short glossary and a short bibliography. The price is very reasonable.

C. CHAPMAN
Blue Hill Meteorological Observatory

GLEANINGS FOR A. T. M.s

The Eyepiece Problem

1. Eyepieces for Amateur Telescopes

After constructing a telescope, one of the pressing problems of the amateur is to select a suitable set of eyepieces to go with it. Eyepieces are commercially available, but not in any particular profusion of types or focal lengths, and not always easily procured, especially at the present time. Furthermore, a good set of half a dozen eyepieces will cost from $25.00 to $50.00. With a little effort, the amateur can make his own for a fraction of this cost, and find that they will be of quite satisfactory quality. Moreover, he can select what focal lengths and types he wishes.

2. Types of Eyepieces

Single lens eyepieces, commonly called solid oculars, are occasionally used in large telescopes, especially for extremely high magnification. To be satisfactory, however, they must be cemented combinations of particular types of optical glass, otherwise a great deal is sacrificed in definition and field of view. They are not generally suitable for amateur manufacture.

Compound eyepieces are usually much easier to make, and more satisfactory to use, providing a much larger field of view — 40° to 50° — and good corrections for aberrations.

There are two common types of compound eyepieces in general use, the Huygens and the Ramsden. The Huygens is a negative eyepiece, which means simply that it cannot be used as a simple magnifier, the real image being formed inside the eyepiece between the two lenses. The Ramsden is a positive eyepiece, wherein the real image is formed outside the eyepiece where it is available to a reticle or a screen. It can be used as a magnifier, although the image plane is so close to the field lens that it is not very satisfactory in this application.

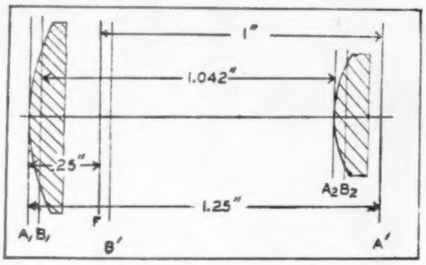
Both these eyepieces consist of two thin plano-convex lenses separated by a considerable distance. Both lenses are made of the same kind of glass and their focal lengths are in simple ratios to one another.

3. The Huygens Eyepiece

The Huygens eyepiece works best with refracting telescopes, and reasonably well with reflectors. Its correction for transverse chromatic aberration is complete, although it has a residue of longitudinal chromatic aberration, some spherical aberration, and small amounts of the oblique aberrations, which it is impossible to remove from the design.

The two thin plano-convex lenses are mounted with their convex sides both facing in the same direction. The one with its convex side out is the field lens; the one with its plano side out is the eye lens, which goes nearest the eye. An eyepiece with a plano side facing the eye is usually the most satisfactory form with respect to the oblique aberrations, and many types of eyepieces are made in this way.

There are two common forms of the Huygens eyepiece. In one, the ratio of focal lengths of field and eye lenses is 3 to 2, in the other, 4 to 1. The former is more satisfactory for higher magnifications, the latter for low magnifications. Data on these two combinations is to be found in Table I, and the two are illustrated in Fig. 1. In the figures, A_1, B_1 are the principal planes of the field lens; A_2, B_2 are the principal planes of the eye lens; **A′ B′**, the principal planes of the eyepiece combination; and **F** is the focal plane of the eyepiece, which is the position of the image formed by the telescope objective. The image formed by the eyepiece, of course, lies at infinity.



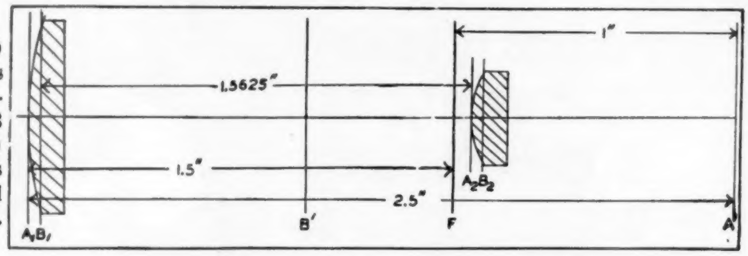


Fig. 1. (Above) The Huygens eyepiece of focal lengths 3 to 2. (Right) The Huygens with focal lengths 4 to 1.

4. The Ramsden Eyepiece

In the Ramsden eyepiece, the two lenses are both placed with their plano

TABLE I — COMMON TYPES OF EYEPIECES

Type	E.F.L.	Focal length, field lens	Focal length, eye lens	Separation	Distance of focal plane from field lens	Distance of primary principal plane from field lens
Huygens	1"	1.25"	.833"	1.042"	—.25"	1.25"
Huygens	1"	2.5"	.625"	1.5625"	—1.5"	2.5"
Ramsden	1"	1.25"	1.25"	.9375"	.25"	.75"
Kellner	1"	1.75"	1.333"	.75"	.4375"	.5625"

Edited by Earle B. Brown

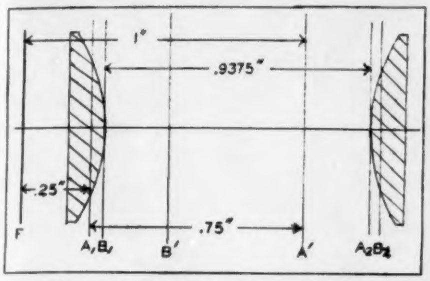


Fig. 2. The Ramsden eyepiece.

sides outward. The most common form of the Ramsden is the one with both lenses of equal focal length. It has better corrections for spherical and oblique aberrations than the Huygens, although the correction for transverse chromatic aberration is not complete. This could only be accomplished in this design by putting the separation equal to the focal length of the two lenses, in which position the focal plane would fall directly upon the field lens, making any dust or defects in the surface of the field lens painfully visible in the field of view. The specifications for this eyepiece are to be found in Table I, and the combination is illustrated in Fig. 2, where the symbols have the same significance as in Fig. 1.

The Ramsden eyepiece is usually found to be somewhat more satisfactory for use with reflecting telescopes than the Huygens. Its eye-distance is usually about 20 mm. — somewhat greater than in the Huygens — which makes for convenience in use.

5. The Kellner Eyepiece

The Kellner eyepiece is a Ramsden in which the eye lens has been made an achromatic doublet to improve the eyepiece with respect to chromatic aberration. In

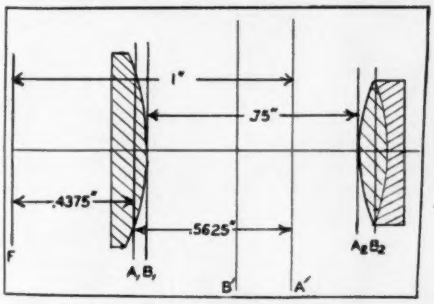


Fig. 3. The Kellner eyepiece.

order to achieve these improved results, the eye lens must be a combination of dense barium crown and light flint glass, which, however, may be obtainable by the amateur. Data on the requisite ratios of focal lengths in achromatic lenses is to be found in **Sky and Telescope,** February, 1942. In this eyepiece the equality of focal length of eye and field lenses is not maintained, as is indicated in the specifications, shown in Table I. The eyepiece is illustrated in Fig. 3, where the symbols have the same significance as in Figs. 1 and 2.

6. Other Types of Eyepieces

There are many special types of eyepieces, most of which are definitely not suitable for reflecting telescopes. The orthoscopic, however, is quite satisfactory, although its principal advantage is that it is well corrected for distortion, which is not a significant factor in astronomical observation, so that its additional cost is not usually justifiable. It has a triplet cemented field lens and a single eye lens.

7. Specifications

The table gives specifications for the two types of Huygens eyepiece mentioned in §3, the Ramsden, as described in §4, and the Kellner, as described in §5, all for an equivalent focal length of one inch. Other focal lengths will have the same specifications, all the measurements being increased or reduced in proportion.

8. Principal Planes

Some explanation of principal planes is advisable. The focal lengths of lenses or of combinations of lenses is measured, not from the center, but from the principal planes. In the diagrams in Figs. 1, 2, and 3, the principal planes are labelled **A** and **B**, subscript 1 referring to the field lens, 2 to the eye lens, and the prime sign (') referring to the combination. Every lens has two principal planes, whose location is a function of the curvature of the two surfaces and the index of refraction of the glass. Every lens and combination of lenses also has two focal lengths, one in each direction, and these two focal lengths are measured from the principal planes, the focal length lying to the left in the diagrams being measured from the primary principal plane, **A** (the principal plane associated with the left-hand surface); the focal length lying to the right being measured from the secondary principal plane, **B** (the principal plane associated with the right-hand surface). For a plano-convex lens, the principal plane associated with the convex surface is at the pole of this surface, and that one associated with the plane surface is 1/N times the thickness from that surface. For an optical system, such as represented by our eyepieces, these principal planes are frequently "crossed," as they are in each case illustrated here, the primary principal plane being on the right and the secondary principal plane on the left.

CORRECTION

We have received the following note from Dr. Charles H. Smiley, of Ladd Observatory, Brown University:

"Because the material on the Schwarzschild camera in the January issue may be in part misleading, may I point out that the mimeographed material quoted there was prepared early in 1940 when Mr. Hoag was working on the primary mirror for our Schwarzschild. Actually the telescope was a joint undertaking in which a number of Skyscrapers participated. In particular, J. Frank Morrissey and Edwin Stevens made the aluminum tube, mirror cells and mount; Harry MacKnight and F. W. Hoffman made the clock drive; Arthur Hoag made the primary mirror and I made the secondary.

"Also, it should be noted that our Schwarzschild was completed in time to be taken to Brazil for the total solar eclipse of October 1, 1940."

IN FOCUS

(Continued from page 2)

the picture: Gambart, 1⅛, 2¾, a ring plain 16 miles across; Reinhold, 2¼, 5½, another ring plain 30 miles in diameter, with terraced walls. It has a low, wide central peak. Note the many small mountains to the south and west, similar to those east (right) of Copernicus. Landsberg, 1, 6⅞, with walls nearly 10,000 feet high; Hortensius, 3¾, 7⅛, 10 miles across, with some rays radiating from it. Halfway between Hortensius and Reinhold is barely visible a ring which may be a submerged crater. Another feature considered a ruined ring plain is Stadius, 2½ inches to the west (left) of Copernicus; it is marked by a vague circle of part crater pits, part curved walls.

In the lower half of the picture (measuring from bottom and left edge) are: Pytheas, 2½, 3⅞, which appears as a bright round spot at full moon; Lambert, ⅜, 3½, at the end of a long ridge and well out on Mare Imbrium; between it and Timocharis is a very bright mountain, which is a bright spot at full moon. Euler, 1⅛, 6⅜; T. Mayer, 4, 7⅛, with a small, distinct crater adjoining it; Gay Lussac, 5, 4⅜, with an interesting interior.

From T. Mayer to Gay Lussac and beyond, for 125 miles, extend the Carpathian Mountains, some peaks rising to 7,000 feet, and the range forming the southern boundary of Mare Imbrium.

BEGINNER'S PAGE

By Percy W. Witherell

Man and His Expanding Universe — III

ONCE upon a time it was thought that the wide dispersion of the brown races among the islands of the Pacific Ocean was the result of wind-blown castaways landing on the scattered islands, as they showed evidences of a common ancestry. As our understanding of their language, songs, customs, and myths has increased, we are impressed with the astronomical knowledge they possessed. Living out of doors on an island with nothing to interfere with good seeing was conducive to watching the movements of the stars and planets.

These "primitive" people knew intimately several hundred stars — their positions, colors, relative brightnesses, and the time of year that they were visible. They were familiar with the constellations and applied picturesque names to them. Stars that rose from the same "pit" on the horizon and passed through the zenith of any particular island were of special value in navigation, as they would pass also through the zenith of all places of the same latitude. Those stars that could be utilized at the different seasons were well known. The motions of the planets were carefully studied.

As with all ancient races, the phases of the moon were used to indicate the lapse of time, and the sun to designate the longer period of the year. Consequently, the distance of the sun north or south of the equator and its position on the ecliptic for every day of the year were known. When the moon was bright enough to obscure the stars, its positions could be used to maintain a course.

The early white explorers were impressed with the natives' almost uncanny meteorological forecasts. This was an ability vitally important to a people who planned to cross the vast Pacific in log canoes. Although many of the predictions were given in verse in relation to certain positions of the constellations, they were based on centuries of observations of the prevailing winds and weather at certain seasons, and the relative locations of the constellations indicated the time of year. Sudden changes of weather were also forecast by the variation in color of a planet due to changes in the upper atmosphere.

The navigation of the Polynesians was so successful that its methods are the basis for some methods of present-day emergency navigation. At the time of year when the winds and weather were apt to be favorable for a particular voyage, the direction for the beginning of the course was indicated by certain landmarks or sometimes by the direction of a channel between two islands. Starting at early dawn, a bright star over the bow was used by the helmsman as a guide. On the return trip, the star used for the outward course was lined up over the stern instead of the bow.

It was customary to sail north or south to the latitude of the chosen island and then to sail east or west to the destination. The north or south course was modified to allow for the prevailing wind and to take full advantage of its direction when the proper latitude was reached.

An ingenious method of accurately deciding when the proper latitude was attained used the "sacred calabash." Four holes were bored at the same height near the neck of a large gourd. When filled with water, the level of the water at these holes gave an accurate horizontal plane. A sight through a hole over the opposite edge at a bright star gave the angle of its height above the horizon. By placing the holes at the right distance below the edge to indicate the latitude of the destination, the time to make the turn east or west could be ascertained.

To determine the approach of spring and the time to plant was necessary in many regions if the people were to survive. Some 4,000 years ago, the Pleiades were in the vicinity of the vernal equinox and their rise in the early morning indicated springtime in the Northern Hemisphere.

Almost universally the Polynesians began the new year near December 1st, with the first new moon after the first appearance of the Pleiades in the eastern sky in the evening twilight. In a few exceptions, the year began in June with the first new moon after the Pleiades appeared on the eastern horizon just before sunrise, or opened with the new moon after the morning rising of Rigel in June.

In the Hawaiian Islands, 12 lunar months of 30 days each were used, and the religious year was correlated with the sidereal year by introducing five extra days. The month was divided into three periods of 10 days each, named "growing," "round," and "decreasing" moon, respectively.

An observatory was a stone platform with a clear view of the eastern horizon. An extraordinary event, such as a comet, might be engraved on lava; perhaps the petroglyphs on Hawaii are such records.

The Milky Way was called Kuamoo, backbone of the lizard, by the Hawaiians, and the dark rift was called the shark or crocodile by some of the Polynesians.

The origin of the world was explained by many different legends. Although the characters and details vary, some of the fundamental ideas are very similar. A primitive egg was a natural beginning. The darkness on the earth was removed by the raising of the sky and letting in the light of dawn. In a volcanic region where islands suddenly appear, or disappear into the sea, myths relating the destruction of the earth's inhabitants by fire and water and its later restoration are a natural occurrence.

The observations and thought of the Polynesians exemplified in these myths, comparing favorably with those of the white man; the island people's practical astronomical knowledge and its application to a navigation that enabled them to voyage thousands of miles across the Pacific Ocean, superior ability to that of our early ancestors; their splendid physical condition and happy community lives until exposed to the diseases and vices of the white race; all these demonstrate the necessity of a little humbleness on the part of the Caucasians and a mite of caution as to the wisdom of forcing its standards of "civilized" life on people who do not want it.

AMERICAN ASTRONOMERS REPORT

(*Continued from page 11*)

sumes a distortion of the apparent star field of the sky lasting at least during the exposure time of 20 to 40 minutes for all plates of one night. He mentioned that, incidentally, another source of systematic errors consists of differential shifts of the plate emulsion after exposure.

Each parallax plate taken at Sproul Observatory, Swarthmore College, is turned by 180 degrees in its own plane between two sets of exposures. By this procedure, it is possible to separate the amounts of the accidental, the plate-emulsion-shift, and the night errors. The present night errors are found to be on the average of the order of 1/100 of a second of arc. A preliminary step in reducing this refraction effect, Dr. Land suggests, would be to conduct experiments to try to determine the location of the refraction disturbances in the atmosphere itself.

A paper by Dr. Dirk Brouwer and Louise F. Jenkins, also of Yale, presented evidence as a corollary to Dr. Land's work. A visual double star, Struve 2398, whose components are about two millimeters apart on the parallax plates, was studied. A strong correlation between the discordance of the measurement of the separation of the two components and the distortion of the larger field of stars on the plate was found, possibly also due to an atmospheric effect.

DEEP-SKY WONDERS

THIS month finds the following objects in good position for observation with moderate-sized telescopes. Descriptions are from Norton's **Star Atlas.**

Gemini. M35, $6^h\ 5^m.7$, +24° 21′. A fine open cluster of bright stars in streams, with many fainter stars. Eas'ly visible to the naked eye, near the summer solstice and the star Eta Geminorum.

N.G.C. 2392, $7^h\ 26^m.2$, +21° 2′. An oval planetary nebula, about 25″ in diameter, with central star of magnitude 9.5.

Cancer. M44 (Beehive), $8^h\ 37^m.2$, +20° 10′. The Praesepe of the ancients. A large, scattered cluster almost resolved by the naked eye. It contains some orange stars, and is best observed with very low power.

M67, $8^h\ 48^m.5$, +12° 0′. Another low-power object, a roughly circular, open cluster of faint stars, diameter, 27′.

Canis Major. M41, $6^h\ 44^m.9$, —20° 42′. An open cluster of bright stars, just visible to the naked eye. There is a ruddy star near the center.

STARS FOR FEBRUARY

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern war time.

Jupiter at Opposition

THE OPPOSITION of Jupiter on February 11th at 6:00 p.m. will find the planet 40 million miles farther away than it was at the very close opposition in September, 1939, when it was at approximately its nearest distance to the earth. At the current opposition, the separation will be 405,933,840 miles, based on an astronomical unit of 93 million miles.

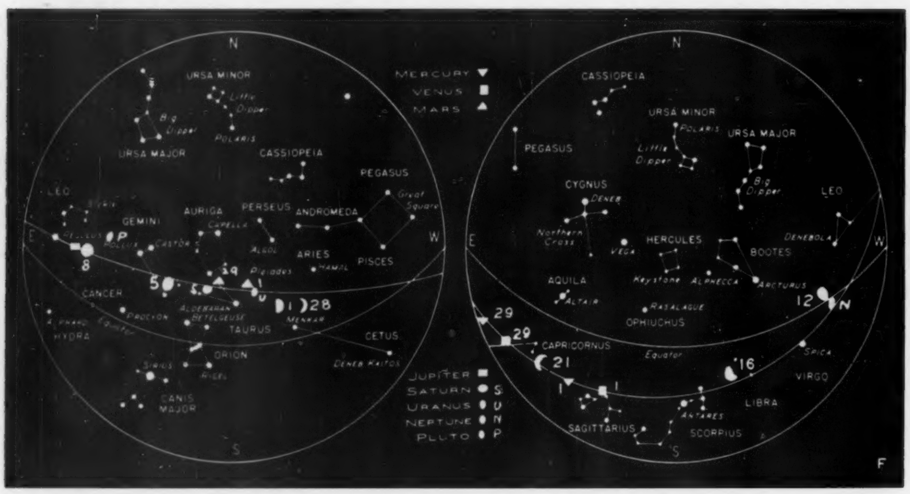
For the amateur, the most interesting feature of this event is the absolute proof that the planet is in opposition to the sun, provided by the transit of moon **I**. Due to the relative positions of the earth and Jupiter in their orbits, we usually see the shadow of one of the satellites start to transit **earlier** than we see the actual disappearance, when this occurs before opposition; and **later**, after opposition. When the angle between the sun and the earth as seen from Jupiter is maximum, about 11°, as it was last November and will be again in May, the shadow cast by **I** enters the disk an hour and a quarter either before or after we see the satellite itself disappear in transit. This time interval decreases to zero at opposition.

As noted above, the opposition is at 6:00 p.m. Twenty nine minutes earlier, at 5:31 p.m., moon **I** will begin to transit the planet's disk from east to west. But at the same moment, its shadow will start to cross, showing the angle between the earth and sun as seen from Jupiter has been reduced to 0°. When the satellite emerges from the transit at 7:48 p.m., the hour will still be so near the moment of opposition that the shadow will appear to leave the disk at the same time. Daylight will interfere with our observation of the immersion, but the emersion can be seen easily if weather permits.

It is well to remember that during the simultaneous transit of the moon and its shadow, the former will partially eclipse the latter, and the shadow will not be seen as a clean-cut circular black spot on the disk, as when observed under different conditions. The reason for this partial eclipse is that the earth, at the time of the opposition, is only half a degree south of the plane of the satellite's orbit as seen from the planet.

Also interesting to watch and to time carefully will be the emergence of moon **I** on the west limb. Because of its diameter, 2,300 miles, and speed in its orbit, 39,000 miles per hour, the satellite will take more than three minutes to show entirely clear of the disk. And during this interval the beginner can appreciate that this tiny moon actually appears as a disk in his telescope, instead of the star-like object he has been observing when it is in the clear east or west of Jupiter. There will first be seen a slight irregularity on the planet's circular edge, which soon becomes a semicircular excrescence, to be followed in another short interval by the sight of the fully rounded disk. This phenomenon can be seen in a telescope as small as a 3-inch, but I recommend a magnification of at least 100x.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 8:30 a.m. on the 7th of the month, and at 7:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury is too close to the sun for observation.

Venus is still to be seen for a short period before sunrise. It is in Sagittarius and Capricornus.

Mars is in Taurus and north of the Hyades at the beginning of the month. It will be in conjunction with and 8° north of Aldebaran on February 11th. Its magnitude then will equal that of Capella, +0.2. By the end of the month it will have diminished to +0.6.

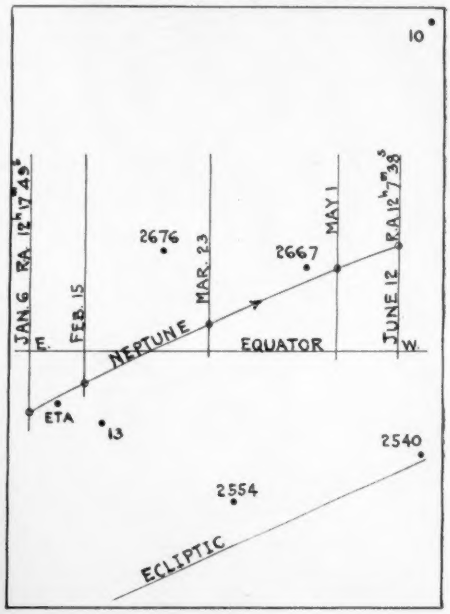
Jupiter. See special article in this issue.

Saturn, in Taurus, will resume its progressive motion on the 20th. Its magnitude, +0.1, will make it slightly brighter than Vega, the brightest star in our summer skies.

Uranus. See special article in the January issue.

Neptune. See special article and diagram in this issue.

THE PATH OF NEPTUNE



THE RETROGRADE motion of Neptune from January 6th to June 12th is shown on the diagram. On the latter date, the planet will resume its normal course toward the east. It will move entirely within the constellation Virgo, and its net progressive movement since opposition on June 11, 1943, will be only 2° 1'.5.

Neptune will be in opposition to the sun on March 23rd, when the planet's magnitude will be +7.7, and its distance from the earth, 2,722,000,000 miles.

The amateur should have no trouble in locating Neptune if he watches for the conjunction with Eta Virginis, magnitude 4.0, on February 3rd, when the planet will be 3' 13" north of the star. It will be recalled that, as mentioned in H. M. Priest's note in the December, 1943, issue of **Sky and Telescope,** Neptune was 11" south of the star on December 10th, a separation so close as to give the appearance of a binary. On February 21st, the planet will be 19' 16" north of 13 Virginis, magnitude 5.92, and on April 19th it will be 6' 25" south of BD +1° 2667, magnitude 9.19.

The four stars shown on the diagram and not mentioned in the previous paragraph are BD +1° 2676, magnitude 8.02; BD —0° 2554, magnitude 7.61; BD —0° 2540, magnitude 8.9; and 10 Virginis, magnitude 6.13.

OCCULTATIONS FOR TEXAS

BECAUSE of the interest displayed last year by Texas residents, their reports submitted to Dr. Alice Farnsworth, Mt. Holyoke College, South Hadley, Mass., and the continued need for more occultation observations and observers, **Sky and Telescope** publishes this month predictions of occultations for the Texas area. Monthly publication will be continued if interest warrants.

The data given below were computed voluntarily by Miss Tecla Combariati and J. Lynn Smith, of the U. S. Naval Observatory, and sent to us by the superintendent of that institution. Predictions are for longitude 98° 0'.0 W., and latitude 30° 0'.0 north. The predictions are similar in form to those given in the **American Ephemeris** for 1944, pages 365-372. All visible occultations of stars brighter than 6.5 are given here, except those occurring within 48 hours of new moon and within 24 hours of full moon.

Due to space considerations, the occultations are not in tabular form. The data include: date, name of star, magnitude; G.C.T. in hours and minutes, **a** and **b** quantities in minutes, and position angle in degrees, at immersion; G.C.T., **a** and **b** quantities, and P.A., at emersion.

Feb. 3, 63 Tauri, 5.7; 5:28.1, —1.5, —0.1, 70°; 6:40.0, —0.7, —1.2, 274°.

Feb. 3, m Tauri **m**, 5.0; 23:33.5, —0.5, +3.0, 34°; 0:38.1 (4th), —2.6, —0.2, 288°.

Feb. 5, Chi² Ori, 4.7; 1:45.7, —1.9, +1.7, 68°; 3:18.9, —2.8, 0.0, 271°.

Feb. 11, 308 B Leo, 5.9; 10:42.2, —2.0, —1.2, 97°; 11:56.3, —0.6, —2.5, 321°.

Feb. 12, b Vir, 5.2; 11:39.3, —0.5, —3.5, 165°; 12:35.3, —1.7, —0.5, 254°.

Feb. 14, 80 Vir, 5.8; 14:57.3, —0.7, —2.9, 154°; 15:46.9, —0.3, —0.4, 248°.

Feb. 17, 49 Lib, 5.5; 12:40.2, —1.8, —1.8, 141°; 14:00.2, —2.6, —0.2, 261°.

Feb. 20, 33 Sgr, 5.8; 12:02.0, —1.1, +0.6, 101°; 13:16.8, —1.8, +0.6, 273°.

MINIMA OF ALGOL

February 12, 4:54 a.m.; 15, 1:43 a.m.; 17, 10:33 p.m.; 20, 7:22 p.m.

OCCULTATIONS — FEBRUARY, 1944

Local station, lat. 40° 48'.6, long. 4ʰ 55ᵐ.8 west.

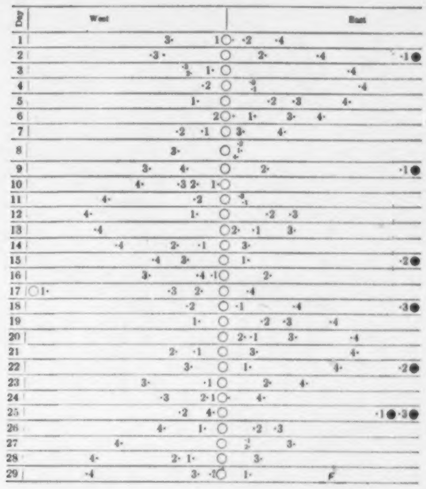
Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Feb. 2	6.8	BD +15° 607	9:38.0 p.m.	75°		
2	6.9	BD +16°579	11:47.6 p.m.	45°		
3	5.0	m Tauri	8:30.7 p.m.	28°	9:33.7 p.m.	304°
4	5.9	57 Orionis	5:11.9 p.m.	42°	6:08.8 p.m.	293°
4	4.7	Chi² Orionis	10:57.5 p.m.	38°	11:58.8 p.m.	317°
5	5.7	68 Orionis	3:34.2 a.m.	113°	4:30.2 a.m.	254°
7	6.1	209 B Geminorum	1:24.7 a.m.	142°	2:29.6 a.m.	244°
7	5.6	Theta Cancri	6:16.6 p.m.	134°	7:02.5 p.m.	231°
28	7.3	BD +11° 434	9:05.3 p.m.	101°		
28	5.9	BD +11° 445	11:22.2 p.m.	122°	0:02.4 a.m. (29)	213°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

JUPITER'S SATELLITES

Throughout the evenings of February 5th and 19th, the four moons will be east of Jupiter. During the evening of the 9th, moons **II, III,** and **IV** will be west of the planet, and following the egress of **I** at 1:22 a.m. on the 10th, the four moons will all be on the west side and in numerical order, **I** being nearest the primary.

Jupiter's four bright moons have the positions shown below at 2:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.



PHASES OF THE MOON

First quarter .... February 1, 3:08 a.m.
Full moon ...... February 9, 1:29 a.m.
Last quarter .... February 17, 3:42 a.m.
New moon ...... February 23, 9:59 p.m.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ THE BUHL PLANETARIUM presents in *February*, AIRWAYS IN THE SKY.

The facilities of the planetarium are used this month to reveal the close connection between the stars and the new air world which is opening up so rapidly. Our ideas of geography have changed enormously in the last few years, changed mainly through the needs and possibilities of the modern airplane. The swift strides in aviation have made such things as great circle routes of fundamental importance and direct interest to each of us. In this production, the sciences of geography and astronomy are combined, to show how the airplane navigator, today and in the world of tomorrow, must depend on things celestial — to show graphically how maps of the earth and maps of the sky are more intimately related than most of us realize.

In connection with this sky show, an extensive exhibit will open in the planetarium galleries, entitled "Airways to Peace." The exhibit consists of six sections: How Man Has Drawn His World, The Progress of Flight, War Over the World, Air Strategy, The Nature of the Atmosphere, Transition to Peace.

★ THE HAYDEN PLANETARIUM presents, in *February*, THE STORY OF THE EARTH. (See page 12.)

In *March*, OUR PLANETARY NEIGHBORS. Last month we singled out the earth among the planets. This month our discussion involves the other members of our sun's family. With telescopic photographs we will study torrid-frigid Mercury, cloudy Venus, ruddy Mars, gigantic Jupiter, beautiful Saturn, Leverrier's (or was it Adams'?) Neptune, and distant Pluto. Are there other planets? We do not know, but we can speculate on such a possibility.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Saturdays (except Tuesdays) ....3 and 8:30 p.m.
Sundays and Holidays ....3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Manager,* Frank S. McGary; *Public Relations,* John F. Landis; *Chief Instructor of Navigation,* Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation,* Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ....2, 3:30, and 8:30 p.m.
Saturdays ....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays ....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Associate Curator,* Marian Lockwood; *Assistant Curator,* Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant,* Fred Raiser; *Lecturers,* Charles O. Roth, Jr., Shirley I. Gale, John Saunders.